BRITISH COLUMBIA SEABIRD COLONY INVENTORY: REPORT #4 - SCOTT ISLANDS

Census Results from 1982 to 1989 with Reference to the Nestucca Oil Spill

Michael S. Rodway
Moira J.F. Lemon
Ken R. Summers

TECHNICAL REPORT SERIES No. 86
Pacific and Yukon Region 1990
Canadian Wildlife Service

Environment Canada
Environnement Canada
Canadian Wildlife Service
Service Canadien de la faune
Canada

TECHNICAL REPORT SERIES
CANADIAN WILDLIFE SERVICE

This series of reports, established in 1986, contains technical and scientific information from projects of the Canadian Wildlife Service. The reports are intended to make available material that either is of interest to a limited audience or is too extensive to be accommodated in scientific journals or in existing CWS series.

Demand for these Technical Reports is usually confined to specialists in the fields concerned. Consequently, they are produced regionally and in small quantities; they can be obtained only from the address given on the back of the title page. However, they are numbered nationally. The recommended citation appears on the title page.

Technical Reports are available in CWS libraries and are listed with the DOBIS system in major scientific libraries across Canada. They are printed in the official language chosen by the author to meet the language preference of the likely audience. **To determine whether there is significant demand for making the reports available in the second official language, CWS invites users to specify their official language preference. Requests for Technical Reports in the second official language should be sent to the address on the back of the title page.**

SÉRIE DE RAPPORTS TECHNIQUES
DU SERVICE CANADIEN DE LA FAUNE

Cette série de rapports donnant des informations scientifiques et techniques sur les projets du Service canadien de la faune (SCF) a démarré en 1986. L'objet de ces rapports est de promouvoir la diffusion d'études s'adressant à un public restreint ou trop volumineuses pour paraître dans une revue scientifique ou l'une des séries du SCF.

Ordinairement, seuls les spécialistes des sujets traités demandent ces rapports techniques. Ces documents ne sont donc produits qu'à l'échelon régional et en quantités limitées; ils ne peuvent être obtenus qu'à l'adresse figurant au dos de la page titre. Cependant, leur numérotage est effectué à l'échelle nationale. La citation recommandée apparaît à la page titre.

Ces rapports se trouvent dans les bibliothèques du SCF et figurent aussi dans les listes du système de référence DOBIS utilisé dans les principales bibliothèques scientifiques du Canada. Ils sont publiés dans la langue officielle choisie par l'auteur en fonction du public visé. **En vue de déterminer si la demande est suffisamment importante pour produire ces rapports dans la deuxième langue officielle, le SCF invite les usagers à lui indiquer leur langue officielle préférée. Il faut envoyer les demandes de rapports techniques dans la deuxième langue officielle à l'adresse indiquée au verso de la page titre.**

Cover illustration is by R.W. Butler and may not be used for any other purpose without the artist's written permission.

L'illustration de la couverture est une œuvre de R.W. Butler. Elle ne peut dans aucun cas être utilisée sans avoir obtenu préalablement la permission écrite de l'auteur.

BRITISH COLUMBIA SEABIRD COLONY INVENTORY:

REPORT #4 - SCOTT ISLANDS.

Census Results from 1982 to 1989 with Reference to the Nestucca Oil Spill.

Michael S. Rodway
Moira J.F. Lemon
Ken R. Summers

Technical Report Series No. 86
Pacific and Yukon Region 1990
Canadian Wildlife Service

This series may be cited as:

Rodway, M.S., M.J.F. Lemon and K.R. Summers. 1990. British Columbia Seabird Colony Inventory: Report #4 - Scott Islands. Census results from 1982 to 1989 with reference to the Nestucca oil spill. Technical Report Series No. 86. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Printed on recycled paper

Published by Authority of the
Minister of Environment
Canadian Wildlife Service

Minister of Supply and Services Canada 1990
Cataloque No. CW69-5/86E
ISBN 0-662-17406-2
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service
Pacific and Yukon Region
P.O. Box 340
Delta, British Columbia
Canada V4K 3Y3

90-06320/2

DEDICATION

This volume is dedicated to the memory of Anne Vallée who died from an accidental fall while conducting studies of Tufted Puffins on Triangle Island. Her spirit resides there still, and if you listen carefully in the early hours of the morning you can hear laughing French songs mixed with the chorus of seabird calls.

ABSTRACT

The Scott Islands are the most important breeding grounds for seabirds in British Columbia. The outer three islands support over two million breeding birds, comprising 38% of the total seabird breeding population in the province. They are the most important colonies for Cassin's Auklets (*Ptychoramphus aleuticus*) in the world, housing 58% of their estimated world population. Triangle Island supports the majority of Common Murres (*Uria aalge*) and Tufted Puffins (*Fratercula cirrhata*) breeding in British Columbia, and is the only breeding site for Thick-billed Murres (*Uria lomvia*) in the province. Breeding populations may have been larger in the past prior to the introduction of mink (*Mustela vison*) and raccoon (*Procyon lotor*) to Cox and Lanz islands in the 1930's.

That dense concentration of breeding seabirds is highly vulnerable to local contamination of the marine environment. Oil from the barge "Nestucca", which was damaged off the Washington coast in late December 1988, spread along the length of the west coast of Vancouver Island in January and February 1989. Almost 13,000 seabirds, mostly Common Murres and Cassin's Auklets were known to have died in Washington and British Columbia. Estimated mortality was 30-40,000 birds.

Population studies were conducted on the Scott Islands during the summer of 1989 to assess the impact on local breeding populations. Studies focused on Common Murres and Cassin's Auklets, but information was gathered on other breeding species. Data from all recent surveys by Canadian Wildlife Service were included to provide comprehensive coverage for all species. Results were compared with those from studies conducted in previous years.

In 1989, all species except Common Murres were nesting in larger numbers than previously recorded. Occupancy rates of burrow nesting species were higher and numbers of nests of surface nesting species were greater than those recorded on past surveys. The mortality of Cassin's Auklets during the oil spill had no detectable impact on breeding populations in the Scott Islands.

More Common Murres were counted in 1989 than in previous seasons, but increases were due largely to more complete coverage of colony areas. Comparable counts at specific nesting sites in 1982, 1985 and 1989 were highest in 1982 and lowest in 1985. There was no apparent decline in numbers of murres as a result of the oil spill.

Common Murres were not as successful as other species in 1989. Almost all sites on the east side of the island were abandoned, and the ratio of breeding birds to total birds present on the study site on Puffin Rock was lower than all other values reported in the literature. Lack of comparative data from previous seasons precluded evaluation of those events and their possible relationship to the Nestucca oil spill.

Changes in the number of breeding birds were noted over the seven year time span covered by this report. Most of those changes appeared to be seasonal fluctuations in response to environmental conditions. In 1984, surface nesting species suffered almost total reproductive failure, and breeding efforts of Tufted Puffins and growth rates of Rhinoceros Auklets were low. Those failures were attributed to a week of severe storms at the end of June combined with an apparent shortage of Pacific sandlance (*Ammodytes hexapterus*), the primary prey for most fish-eating species.

Increases in population estimates for Cassin's Auklets between 1977 and 1989, and Tufted Puffins between 1982 and 1989 were largely due to higher burrow occupancy rates in 1989. Occupancy rates are an indication of seasonal breeding efforts, and those increases likely reflect changes in environmental conditions, rather than actual population changes.

For Rhinoceros Auklets (*Cerorhinca monocerata*), increases in population estimates between 1976, 1984 and 1989 appear to indicate actual population change, though they were partially due to more intensive survey methodology.

RÉSUMÉ

Les îles Scott constituent le lieu de nidification le plus important pour les oiseaux de mer en Colombie-Britannique. Les trois îles à l'extrémité de l'archipel accueillent plus de deux millions d'oiseaux nicheurs, c'est-à-dire 38% de la population total des oiseaux de mer nichant dans la province. Ils forment les plus grandes colonies d'Alques de Cassin (*Ptychoramphus aleuticus*) sur le globe et les représentent 58% de la population mondiale selon les estimations. La majorité des Marmettes de Troïl (*Uria aalge*) et des Macareux huppés (*Fratercula cirrhata*) qui nichent en Colombie-Britannique occupent l'île Triangle; cette île est aussi le seul territoire de nidification des Marmettes de Brünnich (*Uria lomvia*) dans la province. Il est possible que les populations d'oiseaux nicheurs aient été plus large dans le passé, avant que le vison (*Mustela vison*) et le raton laveur (*Procyon lotor*) ne soient introduits sur les îles Cox et Lanz dans les années 1930.

La grande concentration d'oiseaux nicheurs est très facilement atteinte par la contamination locale du milieu marin. Le pétrole déversé par le chaland "Nestucca", qui a été endommagé au large des côtes de l'État de Washington à la fin de décembre 1988, s'est répandu tout de long de la côte ouest de l'île Vancouver en janvier et en février 1989. On a constaté que près de 13 000 oiseaux, en particulier des Marmettes de Troïl et des Alques de Cassin ont disparu en Colombie-Britannique et dans l'État de Washington. La mortalité a été de 30 000 à 40 000 oiseaux selon les estimations.

Des études sur les populations qui occupent les îles Scott ont été réalisées durant l'été 1989 afin d'évaluer l'effet de l'accident sur les populations locales l'oiseaux nicheurs. Les recherches ont porté surtout sur les Marmettes de Troïl et les Alques de Cassin, mais on a aussi recueilli des informations concernant d'autres espèces d'oiseaux nicheurs. On a inclus également des données provenant des études récentes effectuées par la Service canadien de la faune, afin de pouvoir renseigner sur toutes les espèces. Les résultats de l'étude ont été par la suite comparés à ceux des années précédentes.

En 1989 toutes les espèces, sauf les Marmettes de Troïl, nichaient en plus grand nombre qu'auparavant. Si l'on compare aux études antérieures, le taux d'occupation des espèces nichant dans un terrier était plus important et une plus grande quantitéd'espèces nichant en surface a été enregistrée. La mortalité des Alques de Cassin lors du déversement de pétrole n'a manifestement pas eu d'effet sur les populations d'oiseaux nicheurs dans les îles Scott.

On a enregistré un plus grand nombre de Marmettes de Troïl en 1989 que lors dans années précédentes mais cette croissance était principalement due à un examen plus complet des aires de colonies. En des points de nidification précis, des recensements similaires effectués en 1982, 1985 et 1989 montraient des chiffres records en 1982 et un creux en 1985. Il n'y a pas eu de baisse apparente du nombre des Marmettes suite au déversement du pétrole.

Les Marmettes de Troïl n'étaient pas aussi abondantes que les autres espèces en 1989. Preque tous les sites de la côte est de l'île ont été abandonnés et le taux d'oiseaux nicheurs comparé à l'ensemble des oiseaux occupant Puffin Rock, le lieu des recherches, était inférieur à tout autre chiffre mentionné dans les livres. Dû à un manque de données permettant la comparaison avec les années précédentes, on n'a pu, suite aux observations, tirer des conclusions ayant un rapport éventuel avec le déversement de pétrole par le "Nestucca".

On a constaté une variation dans le nombre des oiseaux nicheurs au cours des sept années sur lesquelles porte la rapport.

La plupart des changements semblent avoir été le résultat des mouvements saisonniers qui sont dus aux conditions de l'environnement. En 1984, les espèces nichant en surface ont été victimes d'un échec presque total de reproduction, et les tentatives de reproduction chez les Macareux huppés ainsi que les taux de croissance de Macareux rhinocéros ont été minimes. Ces échecs ont été causés par une semaine d'orages violents, à la fin de juin, et accentués par un manque évident de lançons du Pacifique, proie principale de la majorité des espèces piscivores.

L'augmentation des estimations de population relatives aux Alques de Cassin entre 1977 et 1989 et aux Macareux huppés entre 1982 et 1989 a été principalement due à des taux d'occupation de terriers plus élevés en 1989. Les taux d'occupation indiquent les efforts de reproduction saissonnière et ces augmentations découlent probablement des changements dans les conditions de l'environnement, plutôt que de changements dans les populations mêmes.

Dans le cas des Macareux rhinocéros (*Cerorhinca monocerata*), les augmentations des estimations de population qui ont été relevées entre 1976, 1984 et 1989 semblement indiquer une réelle variation de la population, bien qu'elles soiant aussi le résultat d'une méthode de recherche plus approfondie.

Triangle Island from southeast

TABLE OF CONTENTS

ABSTRACT i

RESUME ii

TABLE OF CONTENTS iv

LIST OF TABLES v

LIST OF FIGURES viii

ACKNOWLEDGEMENTS ix

INTRODUCTION 1

METHODS 4

COLONY ACCOUNTS 9

SC-010 TRIANGLE ISLAND 9

Fork-tailed Storm-Petrel 16
Leach's Storm-Petrel 16
Pelagic Cormorant 16
Black Oystercatcher 17
Glaucous-winged Gull 18
Common Murre 21
Thick-billed Murre 26
Pigeon Guillemot 26
Cassin's Auklet 28
Rhinoceros Auklet 49
Tufted Puffin 56

Predation and Mortality 69
Permanent Monitoring Plots 69
Associated species 71
Other birds and mammals sighted 74

SC-020 SARTINE ISLAND 78

SC-030 BERESFORD ISLAND 89

SC-040 LANZ ISLAND 99

SC-050 COX ISLAND 103

SUMMARY AND CONCLUSIONS 106

LITERATURE CITED 108

LIST OF TABLES

SC010-1. Transect parameters on Triangle Island in 1984 12

SC010-2. Transect parameters on Triangle Island in 1989 13

SC010-3. Number of Pelagic Cormorant nests on Triangle Island in 1989 17

SC010-4. Counts of Glaucous-winged Gull on territories on Triangle Island in 1984 18

SC010-5. Contents of Glaucous-winged Gull nests examined on Triangle Island in 1985 19

SC010-6. Glaucous-winged Gull nests counted on Triangle Island in 1989 20

SC010-7. Common Murres counted on visible nesting sites on Puffin Rock in 1982 21

SC010-8. Counts of Common Murres on visible nesting sites on Triangle Island in 1985 21

SC010-9. Location of sites used for photographic counts of murres on Triangle Island in 1989. 23

SC010-10. Photographic counts of Common Murres on Triangle Island in 1989 . . 24

SC010-11. Counts from land of murres not visible from the water during photographic surveys on Triangle Island in 1989 25

SC010-12. Calculation of Common Murre breeding population on Triangle Island in 1989 25

SC010-13. Numbers of Pigeon Guillemots counted around Triangle Island in 1984 26

SC010-14. Numbers of Pigeon Guillemots counted around Triangle Island in 1985 27

SC010-15. Numbers of Pigeon Guillemots counted around Triangle Island in 1989 27

SC010-16. Numbers of Cassin's Auklet burrows in 5x5 m plots along transects in the south bay of Triangle Island in 1984 28

SC010-17. Number of Cassin's Auklet, Rhinoceros Auklet and Tufted Puffin burrows in 2x2 m plots along transects on Triangle Island in 1989 29

SC010-18. Habitat locations of Cassin's Auklet burrows along transects on Triangle Island in 1989 41

SC010-19. Contents of Cassin's Auklet burrows determined in occupancy plots on Triangle Island in 1989 43

SC010-20. Calculations used to derive Cassin's Auklet population estimate on Triangle Island in 1977 44

LIST OF TABLES (cont'd)

SC010-21. Plot data for locations used in the comparison of Cassin's Auklet burrow entrance density on Triangle Island between 1977 and 1989 46

SC010-22. Results of Kruskal-Wallis tests comparing Cassin's Auklet burrow entrances per m^2 on Triangle Island between 1977 and 1989 47

SC010-23. Number of occupied Cassin's Auklet burrows per 25 m^2 plot on Triangle Island in 1977 48

SC010-24. Comparison of Cassin's Auklet burrow occupancy rates (R) determined on Triangle Island in 1977 and 1989 48

SC010-25. Number of Rhinoceros Auklet burrows in 5x5 m plots along transects on Triangle Island in 1984 49

SC010-26. Habitat locations of Rhinoceros Auklet burrow entrances on Triangle Island in 1984 49

SC010-27. Rhinoceros Auklet nest cup contents on Triangle Island in 1984 51

SC010-28. Occupancy of Rhinoceros Auklet burrows along transects, in permanent monitoring plots and growth study plot on Triangle Island in 1984 . . . 51

SC010-29. Habitat locations of Rhinoceros Auklet burrow entrances on Triangle Island in 1989 52

SC010-30. Occupancy of Rhinoceros Auklet burrows along transects on Triangle Island in 1989 53

SC010-31. Number of Tufted Puffin burrows in 5 m segments along 3 m wide transects on Triangle Island in 1982 60

SC010-32. Number of Tufted Puffin burrows per transect section used for density calculations on Triangle Island in 1982 62

SC010-33. Occupancy of Tufted Puffin burrows in 3x5 m plots along transects on Triangle Island in 1982 63

SC010-34. Numbers of Tufted Puffin eggs and chicks found along transects, by date, on Triangle Island in 1982 64

SC010-35. Observations on experimental plots to determine accuracy of the toothpick method of determining burrow occupancy of Tufted Puffins 65

SC010-36. Habitat locations of Tufted Puffin burrow entrances on Triangle Island in 1989 66

SC010-37. Occupancy of Tufted Puffin burrows along transects on Triangle Island in 1989 67

SC010-38. Numbers of burrows in Rhinoceros Auklet permanent monitoring plots on Triangle Island in 1984 and 1989 70

LIST OF TABLES (cont'd)

SC010-39. Numbers of burrows in Tufted Puffin permanent monitoring plots on Triangle Island in 1984 and 1989 70

SC010-40. Numbers of Cassin's Auklet burrows in Cassin's Auklet permanent monitoring plots on Triangle Island in 1989 71

SC020-1. Bearings and total length of transects on Sartine Island in 1987 78

SC020-2. Numbers of Glaucous-winged Gulls counted on territories on Sartine Island in 1987 and 1989 81

SC020-3. Number of Cassin's Auklet burrows in 1x1 m plots along transects on Sartine Island in July 1987 85

SC020-4. Occupancy of Cassin's Auklet burrows along transects on Sartine Island in July 1987 86

SC020-5. Number of Tufted Puffin burrows in 1x1 m plots along transects on Sartine Island in July 1987 87

SC030-1. Number of storm-petrel burrows in 1x1 m plots along transects on Beresford Island in July 1987 91

SC030-2. Occupancy of storm-petrel burrows along transects on Beresford Island in July 1987 92

SC030-3. Glaucous-winged Gull nests and adults on territory on Beresford Island on 8 July 1987 94

SC030-4. Glaucous-winged Gulls on territory on Beresford Island on 11 June 1989 94

SC030-5. Number of Cassin's Auklet burrows in 1x1 m plots along transects on Beresford Island in July 1987 95

SC030-6. Occupancy of Cassin's Auklet burrows along transects on Beresford Island in July 1987 95

SC030-7. Number of Tufted Puffin burrows in 1x1 m plots along transects on Beresford Island in July 1987 96

SC-1. Current summary of seabird breeding populations in the Scott Islands . 107

LIST OF FIGURES

SC-1. Location of the Scott Islands 2

SC010-1. Triangle Island showing place names used in the text 10

SC010-2. Cassin's Auklet colony and transect locations on Triangle Island in 1989 . . . . . Back cover

SC010-3. Rhinoceros Auklet colony and transect locations in the south bay of Triangle Island in 1984 50

SC010-4. Rhinoceros Auklet and Tufted Puffin colony and locations of surface nesting species on Triangle Island in 1989 . . . . . Back cover

SC010-5. Transect locations and Tufted Puffin colony on Puffin Rock in 1982 . . . 57

SC010-6. Transect locations on the east side of Triangle Island in 1982 58

SC010-7. Transect locations in the northeast bay of Triangle Island in 1982 59

SC020-1. Locations of surface nesting species on Sartine Island in 1987 and 1989 79

SC020-2. Cassin's Auklet and Tufted Puffin colony on Sartine Island in 1987 . . . 82

SC030-1. Colony areas and transect locations on Beresford Island in 1987 90

SC040-1. Nest sites and areas explored on Lanz Island in 1987 100

SC050-1. Nest sites and areas explored on Cox Island in 1987 104

ACKNOWLEDGEMENTS

Colony inventories were conducted and permanent monitoring plots were established in the Scott Islands between 1982 and 1987 as part of the Migratory Birds Conservation Program, supervised by K. Vermeer in 1982 and by G.W. Kaiser from 1984-1987, and funded by the Canadian Wildlife Service. In 1989, surveys were funded through contract to Environment Canada, Conservation and Protection, Environmental Protection as part of the impact assessment of the Nestucca oil spill on the British Columbia coast. S. Wetmore, Canadian Wildlife Service was the scientific authority for the contract.

Permission to work on Triangle Island, in the Anne Vallée Ecological Reserve, and the rest of the Scott Islands, was provided by B. Foster in 1982 and 1984, and by L. Goulet from 1985 to 1989.

Various people assisted with field work during the surveys. Their company and enthusiasm was greatly appreciated. Exceptional recognition is deserved by B. Carter and D. Grinnell in 1989, who unflinchingly traversed endless expanses of salmonberry and crabapple to unveil the secrets of the previously uncharted heart of Triangle Island.

1982: A. Vallée.

1984: R. Butler, I. Jones.

1985: J. Rodway.

1987: B. Carter, R. Chaundy.

1989: B. Carter, D. Grinnell, G. Summers.

We would also like to thank the staff at Vancouver Island Helicopters in Port Hardy for their assistance and concern during all field seasons.

Many thanks to G.E.J. Smith who always found time to assist with statistical methodology, and provided many valuable suggestions on survey design. We are grateful to K. Vermeer for sharing unpublished results of 1977 surveys.

INTRODUCTION

The Scott Islands (Fig. SC-1) house the largest concentration of breeding seabirds in the eastern North Pacific south of Alaska. A third of the seabirds breeding in British Columbia nest on the Scott Islands. The outer three Scott Islands are the most important breeding area for Cassin's Auklets (*Ptychoramphus aleuticus*) in the world, supporting approximately 58% of the estimated world population of that species. Triangle Island supports the majority of Common Murres (*Uria aalge*) and Tufted Puffins (*Fratercula cirrhata*) breeding in British Columbia, and is the only breeding site for Thick-billed Murres (*Uria lomvia*) in the province (Rodway *in press*). Breeding populations may have been larger in the past prior to the introduction of mink and raccoon to Cox and Lanz islands in the 1930's (Carl *et al.* 1951).

That dense concentration of breeding seabirds is highly vulnerable to local contamination of the marine environment. Oil from the barge "Nestucca", which was damaged off the Washington coast in late December 1988, spread along the length of the west coast of Vancouver Island in January and February 1989. The condition of the Scott Islands was a major concern, and the islands were monitored for the presence of oil at that time. Small quantities of oil came ashore on Triangle, Lanz, and Cox islands, but clean-up was not required (Rodway *et al.* 1989).

Though the Scott Islands were not heavily impacted by oil, there was a substantial loss of seabirds during the spill. Almost 13,000 seabirds, mostly Common Murres and Cassin's Auklets were known to have died in Washington and British Columbia (Rodway *et al.* 1989). Estimated mortality was 30-40,000 birds (Burger *in prep.*). We conducted population studies on the Scott Islands during the summer of 1989 in an attempt to assess the impact on local breeding populations. Studies focused on Common Murres and Cassin's Auklets, but information was gathered on all breeding species. The shores of Triangle Island were thoroughly searched for oiled carcasses, and live birds were scrutinized for signs of oiling. Permanent Monitoring Plots were established for Cassin's Auklets on Triangle Island, and plots set-up for Rhinoceros Auklets and Tufted Puffins in 1984 were resurveyed.

Results from 1989 studies were compared with those from studies conducted in previous years, to determine whether breeding populations had declined following the Nestucca oil spill. Observations made by Carl *et al.* (1951) are primarily anecdotal but do indicate the status and distribution of some species. Extensive studies on Triangle Island by K. Vermeer of the Canadian Wildlife Service in the 1970's provided population estimates for most species. Vermeer (1979) estimated the nesting populations of Tufted Puffins on Triangle Island in 1975, and Rhinoceros Auklets (*Cerorhinca monocerata*) in 1976. Cassin's Auklets were surveyed in 1977 (Vermeer *et al.* 1979). Common Murres were counted on Triangle Island and Sartine Island in 1975 (Vermeer *et al.* 1976a,b). The determination of the puffin population in 1975 was then not the main objective, but was part of a study to obtain general information on the breeding of Tufted Puffins and Rhinoceros Auklets. The 1975 population estimate was based on field measurements and photographs of large nesting areas as well as on estimates of puffin numbers nesting in single pairs or in small groups at various locations. Only the population on Puffin Rock was determined from actual field measurements. Burrow occupancy was based on placing toothpicks in ceilings of burrow entrances, which was considered not to be a reliable method for determining occupancy at a later date (Vermeer, pers. comm.). Sampling of Rhinoceros and Cassin's Auklet colony areas was more systematic, and results are more comparable to those obtained on subsequent surveys.

Surveys of various portions of the Scott Islands were conducted by the two senior authors in 1982, 1984, 1985 and 1987 as part of the Canadian Wildlife Service Seabird Inventory Program. All breeding species on each island were surveyed during those years, except Cassin's Auklets on Triangle Island. An intensive survey of Tufted Puffins on Triangle Island was conducted between 8 and 31 July 1982. Experimental plots were set up to test the reliability of determining burrow occupancy by placing toothpicks in burrow entrances.

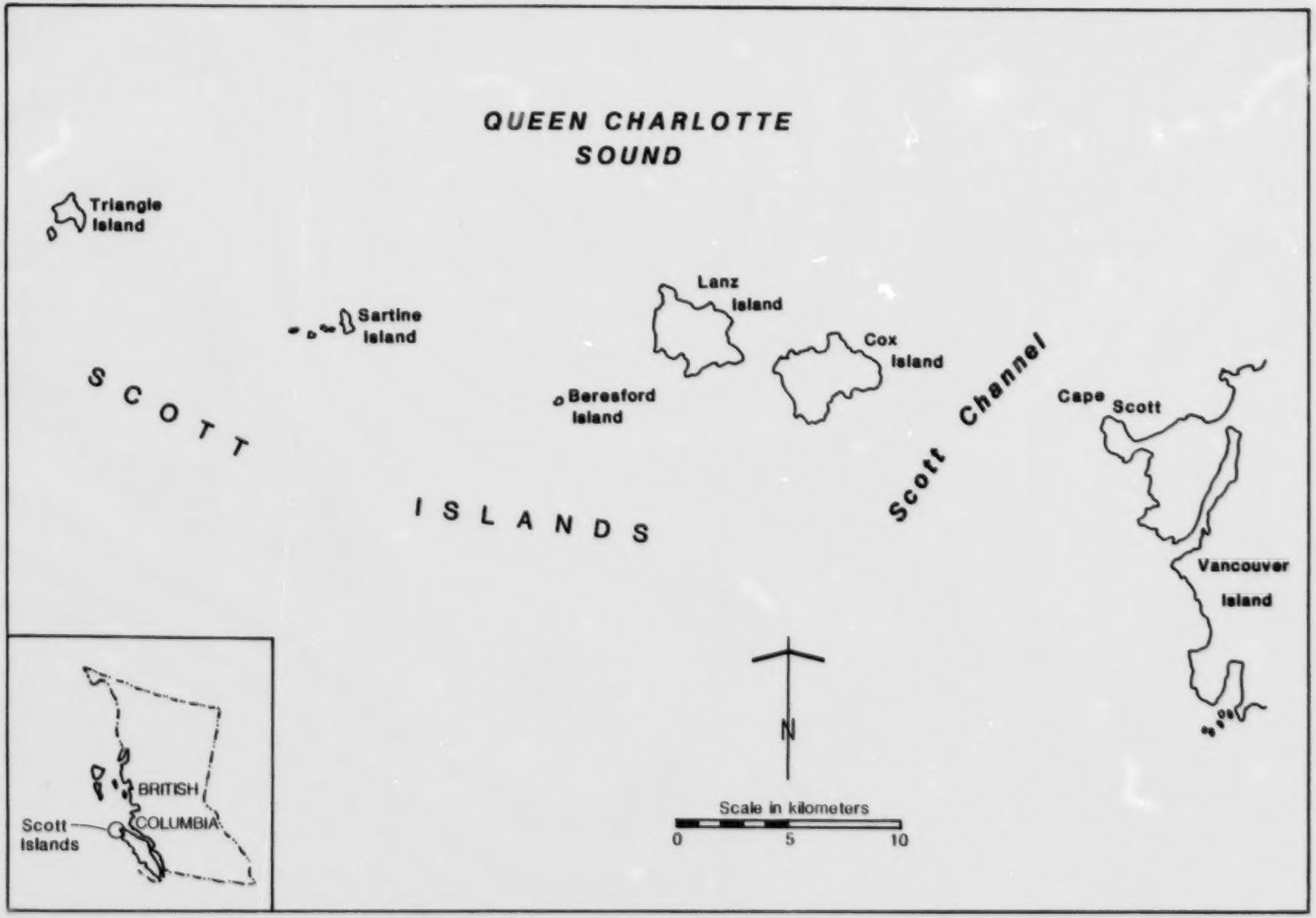

Figure SC-1. Location of the Scott Islands.

Counts of murres and observations of other species were made during the same period. We surveyed the Rhinoceros Auklet colony on Triangle Island in 1984, and returned in 1985 to continue growth studies of Rhinoceros Auklets begun in 1984 as part of a three-island comparative study by Bertram and Kaiser (1988). Observations on surface nesting species were made during both years. The growth study was continued in 1986, but no observations of other nesting species were recorded. The other Scott Islands were explored and their breeding seabirds were censused in 1987.

To facilitate an evaluation of the status of breeding seabirds in 1989 following the Nestucca oil spill, results from all those surveys have been included in this report. This volume is the fourth in a series of technical reports designed to provide detailed information on the status of breeding seabirds in different regions of the British Columbia coast (see Rodway 1988, Rodway *et al.* 1988, 1990). We previously produced a report on the 1982 survey of Tufted Puffins (Lemon *et al.* 1983), but an error in the methodology used for calculating the population estimate presented in that report meant that revisions were required. Those revisions, and the overall results of that survey have been incorporated into this document to provide a detailed presentation of all recent survey data. Detailed results of the study of murre populations conducted in 1989 are presented elsewhere (Rodway 1990). A summary of those results are included here to complete population estimates for all species.

METHODS

Census methods were selected according to the area, habitat, and species of birds nesting on an island (Nettleship 1976). All accessible areas on Triangle, Sartine and Beresford islands were explored to determine distribution of nesting species. On Cox and Lanz islands, we explored most perimeter sections to a distance of 50m from shore, plus frequent sections of the interior up to 200m from shore.

1. Total Count. Total nest counts were made for Brandt's Cormorants (*Phalacrocorax penicillatus*), Pelagic Cormorants (*P. pelagicus*), Black Oystercatchers (*Haematopus bachmani*) and Glaucous-winged Gulls (*Larus glaucescens*), unless nests were inaccessible. Population estimates equal the number of nests counted. In inaccessible areas, numbers of gull nests were estimated to be half the number of adults present. Within the text, lists of nests counted use these abbreviations: Sta - Start; Emp - empty; E - egg; Y - young; Ad - adult; Est - estimated nests; Sus - suspected.

Total numbers of Pigeon Guillemots (*Cepphus columba*) seen around colonies were counted, but no standardized observation techniques were employed (see Nettleship 1976), and no attempt was made to estimate actual nesting populations.

2. Strip transects.

We used 3 m wide strip transects to sample Tufted Puffin colony areas on Triangle Island in 1982. Transects were spaced 20 to 30 m apart on Puffin Rock, and where topography permitted in other areas. All burrows were counted along the transects. Transects were segmented into 5 m sections and burrows were tallied for each section. Previous calculations of burrow density treated each 5 m section as a distinct plot (Lemon *et al.* 1983). This was inappropriate as plots were contiguous along each transect. We recalculated mean burrow density for 1982, treating each strip transect through continuous colony as one sample. Average burrow density was given by:

$$D = \frac{\bar{x}}{\bar{y}}$$

where x is the number of burrows per transect section and y is the area sampled per transect section. The variance and standard error of the density estimate was calculated using the same formula as that used for the variance and standard error of the occupancy rate presented below, substituting the number of burrows counted along each strip for x and the area of that strip for y.

We made extensive measurements of Tufted Puffin nesting habitat on Puffin Rock, and then mapped the colony area in planar view at a scale of 1:1000. On the inaccessible areas of the east and north slopes of Triangle Island, burrowing areas were mapped from observations of puffins sitting on or flying from or to the slopes. For those areas, extrapolations of burrowing density and occupancy were made from sampled areas. Nesting areas were mapped on a 1:2500 scale topographic map. Colony area was determined in the same fashion as described below under line transects, except on Puffin Rock where adjustments for slope were not necessary.

Occupancy rate and total population were calculated as described below under line transects.

3. Line Transects With Quadrats.

Line transects were used to estimate breeding populations of burrowing species on Triangle, Sartine and Beresford islands.

3.1. **Transect location.** Transects were run throughout accessible colony areas. Transects were laid out upslope, generally perpendicular to the shoreline, except across the top of Triangle Island, where we ran parallel transects. We attempted to sample 1% of the area of a colony. That value was the maximum sampling effort we found possible within the time allotted. On Triangle Island, transects were spaced 50 m apart, and were located by measuring the spacing distance along the shore for perimeter transects, and along a line perpendicular to the transect bearings for transects running across the top of the island. On Sartine and Beresford islands, we placed transects by locating reference points plotted on air photos.

3.2. **Quadrats:** Quadrats were set at predetermined intervals along transect lines. Along shore, the first quadrat occurred at the edge of the vegetation, unless that was inaccessible. Plots for different studies ranged in size from 1x1 m to 5x5 m, and spacing varied from 5 m for 1x1 m or 2x2 m plots, to 40 m for 5x5 m plots. The size was selected so that an average of at least one burrow occurred in each quadrat. The density of burrowing encountered in most areas was best sampled with smaller, more frequent plots (Savard and Smith 1985).

Burrows were counted within each quadrat and their entrance characteristics recorded: location (ie, under grass tussocks, tree roots, shrubbery, ferns etc.), accessibility (whether it was obscured, or obstructed), and signs of activity (droppings, feathers, etc.), both at the entrance and in the tunnel. In dense burrowing areas, only entrance location was recorded to reduce the time required to survey plots. Each burrow entrance was explored to elbow length. If within this distance, entrances connected into the same tunnel, only one burrow was recorded and the number of entrances was noted. Habitat parameters were measured: distance from shore, altitude, slope, percent and species composition of ground cover, shrub cover, and forest canopy. To place the quadrat in the context of the overall habitat, tree species, percent composition, and average size (on Beresford Island) , and general terrain features (on all islands) were documented for the area surrounding each quadrat within a radius equal to half the distance between quadrats. Evidence of predation (eggshells, carcasses, feather piles) within each quadrat was recorded. Detailed analyses of habitat data are not included in this report but will be presented in subsequent documents.

3.3. **Colony area**: Colony area was defined to include all portions of an island where burrows with recent signs of activity (droppings, feathers, regurgitated food, fragments of eggshell or egg membrane, worn entrances or tunnels, excavation, or fresh nesting material) were located. If burrows were located, but no signs of recent activity were observed in an area, the colony was considered abandoned. If there were no burrows within a quadrat, the surrounding area was searched for colony evidence to determine if the plot fell within the colony and should be used in density calculations.

Distance, elevation, and slope measurements taken along the transects, as well as during the exploration, were used to draw colony areas on detailed topographic maps or air photos. The horizontal surface area of the colony was measured on that map with a compensating polar planimeter. Colony areas were divided into sections with consistent slopes. Adjusting for slope, the area of individual sections was given by:

$$C_s = A_h T^2 \ (\cos \Theta)^{-1}$$

where C_s is the colony surface area, A_m is the area on the map, T is the scale of the map, and Θ is the mean slope along the transects. The colony area calculations take into account the average uphill slope, but not the undulations between quadrats or between transects. Therefore our calculations give a conservative estimate of the total surface area available to birds for nesting.

There is no measure of error for colony area calculations and its level of precision is unknown. The accuracy of area estimates depends on precise delineation of colony boundaries by thorough exploration, careful observation, and detailed and explicit notetaking, as well as on distance, slope and elevation measurements taken along transects. Accuracy of mapping and measuring colony areas depends on the scale and detail of available topographic maps or air photos. Larger scale maps allow more accurate representation.

3.4. **Burrow density**: Counts from all plots within colony areas were used to calculate average burrow densities. If marked and consistent differences in densities were encountered in different parts of a colony, those areas were separately mapped and individual mean densities were calculated. Assigned density classes are unique to a particular colony and cannot be equated to those designated for other colonies. Their purpose is to demarcate areas of nesting concentration within a colony. Densities are quoted plus or minus one standard error. On figures, burrows/ha is abbreviated to b/ha.

3.5. **Burrow occupancy:** The percentage of burrows that actually contained nesting birds was determined by complete examination of a sample of burrows. If an adult, egg, chick, or freshly hatched egg membrane was found, the burrow was considered occupied. Burrows were considered empty if all tunnel branches were explored and none of the above were found. Signs such as a well worn entrance or droppings were not used to distinguish between occupied and empty burrows. Exploring burrows longer than an arm's reach required digging one or more access holes until the end was reached. Excavated holes were immediately patched with sticks and soil. To minimize disturbance, adults were not pulled from burrows except to confirm species identification.

To obtain a representative sample of the entire colony, we selected plots from different areas of the colony and explored every burrow in each plot selected. Occupancy tables within the colony accounts indicate the distribution of quadrats where occupancy data was obtained.

Occupancy rate was calculated according to the formula:

$$R = \frac{\bar{x}}{\bar{y}}$$

where x_i is the number of occupied burrows in the i^{th} quadrat, and y_i is the total number of occupied plus empty burrows in the i^{th} quadrat and $\bar{x}$ and $\bar{y}$ are, respectively, the mean of the x_i and y_i over all quadrats.

The variance of R is calculated from:

$$\mathrm{Var}(R) = \frac{\bar{x}^2}{\bar{y}^2}\left[\frac{s_x^2}{\bar{x}^2} + \frac{s_y^2}{\bar{y}^2} - \frac{2s_{xy}^2}{\bar{x}\bar{y}}\right]$$

where s_x is the standard error of $\bar{x}$, s_y is the standard error of $\bar{y}$, and s_{xy}^2 is the covariance of $\bar{x}$ and $\bar{y}$ (Kendall and Stewart 1963).

The standard error of R is the square root of Var(R).

On Sartine and Beresford islands, occupancy rates for Tufted Puffins were not determined due to lack of time, and we estimated nesting populations using the occupancy rate calculated for Triangle Island.

3.6. **Total burrows and nesting population estimates:** The total number of burrows (**B**) is the product of the overall average density of burrows, as determined in the quadrats, and the total area of the colony. Total burrows are not calculated separately for low, medium and high density classes because those classes are arbitrarily assigned after surveys are complete. Their function is to indicate relative abundance within the colony. Where different sampling intensities were used for sections of the Cassin's Auklet and Tufted Puffin colonies on Triangle Island, numbers of burrows were calculated using separate densities from each section. **B** multiplied by the occupancy rate, (**R**) gives an estimate of nesting pairs (**P**). Calculations are quoted plus or minus one standard error.

$$P = BR$$

The variance of P is calculated from

$$Var(P) = B^2 Var(R) + R^2 Var(B) - Var(B) Var(R)$$

The standard error of P is the square root of Var(P).

4. Distinguishing species:

The burrows of different species are often mixed. This presents problems for surveyors when burrow contents cannot be determined. Identification of burrows must then be based on indicative signs found in the burrow or at the burrow entrance. We developed a set of criteria for distinguishing burrows of storm-petrels, Cassin's Auklets, Rhinoceros Auklets and Tufted Puffins: size of entrance; wear at the entrance; droppings in and around the burrow entrance; regurgitated food (for Cassin's Auklet); feathers found in the burrow; eggshell fragments found in the burrow; and odour.

Storm-petrels (*Oceanodroma furcata* and *O. leucorhoa*) were found nesting in conjunction with Cassin's Auklets on Beresford Island and both Cassin's Auklets and Tufted Puffins on Triangle Island. Little difficulty was encountered differentiating storm-petrel burrows according to size (5-7cm wide). The musty odour of petrels was also helpful.

Cassin's Auklets were found nesting in the same areas as Rhinoceros Auklets and Tufted Puffins. The size of burrows of those species are generally distinct: Cassin's Auklet burrows are 10-12 cm wide, Rhinoceros Auklet burrows are 12-15 cm wide, and Tufted Puffin burrows are 15-18 cm wide. However, we found Cassin's Auklet nesting in typical Rhinoceros Auklet, and even Tufted Puffin sized burrows, which made identification more complicated. Droppings, regurgitated food, eggshell fragments, and feathers provided more conclusive evidence.

Rhinoceros Auklets and Tufted Puffins have relatively clean burrow entrances compared to Cassin's Auklets, which often leave white fecal streaking along the approach and into the entrances of their burrows. This distinction is less useful in grassy areas, and during rainy weather, since droppings do not accumulate under those conditions. The droppings of Rhinoceros Auklets are large, generally globular, pale yellow with black, viscous blobs, and are

often deposited to one side of the burrow entrance. Tufted Puffin droppings are whitish or yellowish, and are often released during flight or take-off, though they are sometimes deposited near the burrow entrance. Cassin's Auklet droppings have a more arresting odour than either Rhinoceros Auklet's or Tufted Puffin's, as does their regurgitated food, some of which they invariably lose at the entrance to their burrows when delivering it. The entrance and vicinity of Rhinoceros Auklet and Tufted Puffin burrows are more extensively trampled and worn than those of Cassin's Auklets.

Abdominal feathers (which are often lost in burrows) of each species can be distinguished by their colour pattern (size is not reliable). The overall colour of Cassin's Auklet and Rhinoceros Auklet feathers are similar, but the colour pattern of the feather plumules are distinct. Cassin's Auklet plumules are mostly dark with a tip of white, while the colour of Rhinoceros Auklet plumules is uniform greyish white and is similar to that of the base of the main feather. Abdominal feathers of Tufted Puffins have dark rather than white ends. Eggshell fragments of all three species are white and are difficult to distinguish unless a substantial portion of the shell is present and can be identified by size.

5. Predation:

During exploration, notes were kept of all signs of predation or mortality encountered. Areas around Bald Eagle, Peregrine Falcon, and Common Raven nests, and around river otter runs and dens were examined in detail. This gave an indication of the degree and the kind of species being preyed upon. To quantify the level of predation, we calculated the density of prey remains recorded in quadrats, using the minimum possible number of birds represented by the evidence found. We assumed that one feather pile represented one bird. Estimates only allow coarse comparisons between colonies because surveys occurred at various times in the nesting season. It underestimates total predation because plots only sample remains left within the colony before the end of the season.

6. Staging:

Near dusk, during part of the breeding season, Rhinoceros Auklets aggregate on the water adjacent to colony areas, and then circle in large wheels around nesting slopes, in typical puffin fashion (see Harris 1984). We made observations on the timing and number of birds involved in staging and circling behavior on Triangle Island from our camp in the south bay.

7. Photographic counts: In 1989, murres on Triangle Island were censused using the methodology outlined in Birkhead and Nettleship (1980). Total populations were estimated using counts from photographs, adjusted by a ratio of direct counts to counts from photographs determined at a study plot. The proportion of breeding sites to total birds present (k) on the study plot was used to estimate breeding population. Detailed methodology is presented in Rodway (1990).

8. Permanent plots: Permanent plots were purposefully distributed throughout main colony areas. All plots were 10x10 m. Corners were marked with 3 cm aluminum tubing wrapped with coloured tape. Wooden posts with engraved metal tags were placed at lower left corners.

9. Time:

Times quoted are Daylight Savings Time. Subtract one hour from Daylight Savings Time to calculate Pacific Standard Time.

COLONY ACCOUNTS

SC-010 TRIANGLE ISLAND 103 I/14

Location: Outermost of the Scott Islands, 46 km northwest of Cape Scott. 51°52'N 129°05'W

Land status: Provincial Ecological Reserve.

Description: Perched 46 km off the northwest tip of Vancouver Island, Triangle Island is the vanguard of the southern British Columbia coast. It has been described in detail by Carl *et al.* (1951). Perimeter slopes are steep but accessible in many areas, as beaches or tidal rock shelves make it possible to walk around the circumference of the main island. The southwest peninsula ("Puffin Rock"), and the offshore rocks and pinnacles drop more abruptly into the sea (Fig SC010-1). The island rises to a maximum elevation of 194 m and has a total area of 144 ha, 106 of which are vegetated. Bare, offshore pinnacles comprise an additional 5 ha.

From the air, the top of the island "...appears to be covered with a verdant cloak of smooth, grass-like texture, but on close examination it proves to be an almost continuous mantle of salmonberry (*Rubus spectabalis*), closely and evenly wind-pruned to a height of from 2 to 6 feet." Stunted, wild crabapple (*Pyrus fusca*) mixes with salmonberry in many areas, adding to the impenetrability of inner slopes. Elderberry (*Sambucus racemosa*) and twinberry (*Lonicera involucrata*) occur in sporadic pockets. On the highest part of the island, along "Saxifrage Ridge", salmonberry gives way to an expansive area of fragile, heavily burrowed soil, covered with *Saxifraga ferruginea* and Wood Fern (*Dryopteris austriaca*). Similar habitat occurs above the steep slopes along the west side of the island. Extensive hummocks of Licorice Fern (*Polypodium vulgare*) and ground-hugging salal (*Gaultheria shallon*) also occur along Saxifrage Ridge.

Calamagrostis nutkaensis is the dominant grass species on the top of the island, covering substantial areas on the east side of Saxifrage Ridge and on the southeast ridge. Many perimeter slopes are grassy, primarily Tufted Hairgrass (*Deschampsia caespitosa*), especially in the west and south bays, and over much of Puffin Rock. Salmonberry covers precipitous slopes in the south bay and along the north side, expanses of Lady Fern (*Athyrium felix-femina*) grow on north and northwest slopes and in the central area of Puffin Rock, and stunted salal grows on steep, exposed rocky ridges on all sides of the island.

Vegetation structure changes over the seabird breeding season in response to activities of nesting species. In Rhinoceros Auklet colony in the south bay, *Maianthemum dilatatum* grows profusely among tussocks of Tufted Hairgrass in June. By mid-July, after chicks have hatched and adults are visiting the slopes more frequently to feed them, areas between grass tussocks are worn bare and almost no evidence of *Maianthemum* remains. In 1984, we were puzzled by the fact that 12% of Rhinoceros Auklet burrows had *Maianthemum* in their nest cups, yet there was very little *Maianthemum* in the area. It was not until 1989, when we were present in June that we observed the earlier abundance of that species.

On Saxifrage Ridge there are extensive patches of bare, hummocky, fern roots in June when Cassin's Auklets are feeding young. In August, after chicks have fledged and the area is less disturbed, young Licorice Fern (*Polypodium vulgare*) fronds carpet the hummocks.

A lighthouse was built on the top of the island in 1909-1910. After nine years of operation, with despairing lightkeepers tormented by wind, rain and fog, it was dismantled. The concrete base remains a silent testimony to their efforts.

Triangle Island became an Ecological Reserve in 1971. It was renamed the Anne Vallée Ecological Reserve in tribute to Anne who died in 1982 while studying the puffins she loved.

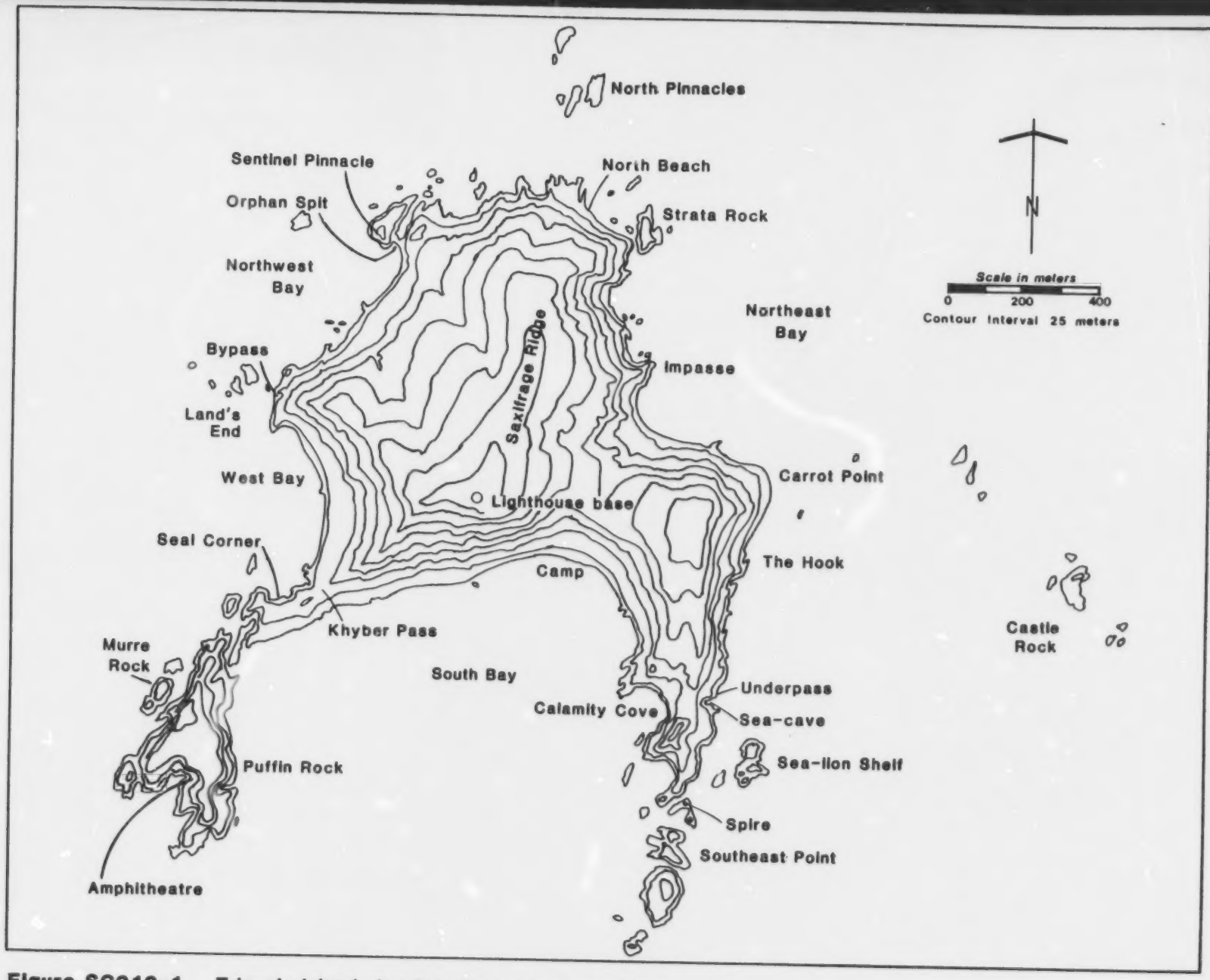

Figure SC010-1. Triangle Island showing place names used in the text.

Date of visit: 8-31 July 1982 (transects for Tufted Puffins and single count of Common and Thick-billed murres); 5-29 July 1984 (transects for Rhinoceros Auklets, permanent plots for Rhinoceros Auklets and Tufted Puffins, and counts of cormorant and gull nests and numbers of murres and guillemots); 9-25 July 1985 (counts of cormorant nests and numbers of murres and Pigeon Guillemots); and 4 June to 21 August 1989 (transects and permanent plots for Cassin's Auklets, Rhinoceros Auklets and Tufted Puffins, photographic count, attendance patterns, and nesting chronology of Common Murres, and counts of Pelagic Cormorant, Black Oystercatcher and Glaucous-winged Gull nests and numbers of Thick-billed Murres and Pigeon Guillemots). Triangle Island was also visited 6-22 July 1986 to carry on growth studies of Rhinoceros Auklets begun in 1984 as part of a three island study (see Bertram and Kaiser 1988).

Colony access: Boat landings can be made in calm seas at the camp in the south bay. Landings are easier at high tide. Helicopters can safely land near the camp in the south bay except during strong northwest winds which create severe downdrafts on the south side of the island.

Base camp: For recent studies, base camps have been established in the south bay. The northeast bay was used by surveyors in 1949 (Carl *et al.* 1951), and is a suitable site, but is farther from study areas for most species. Seepage water is generally available, but can be a problem during dry weather. It is most dependable in the northwest bay.

Sensitivity: The intense concentration of breeding seabirds on Triangle Island make the colony vulnerable to almost any form of human visitation. It is almost impossible to walk anywhere on main nesting slopes without collapsing burrows. Frequent human traffic destroys burrowing habitat. Murres, puffins, gulls and cormorants are easily disturbed by closely approaching boats, planes or helicopters.

Observers: 1982: M. Lemon, M. Rodway, A. Vallee; 1984: M. Lemon, M. Rodway, R. Butler, I. Jones; 1985: M. Rodway, J. Rodway; 1989: M. Rodway, K. Summers, B. Carter, D. Grinnell.

Census methods: In all years, colony areas were mapped on a 1:2500 scale topographic map with 5 m contour intervals.

1982: Strip transects, 3 m wide, were run from the base of the vegetation on all accessible nesting slopes until no more puffin burrows were found. All burrows were counted for each 5 m segment along transects. Plots were smaller than 3x5 m at the beginning and end of some transects where the transect left puffin habitat before the end of the 5 m segment. Slopes and elevations of each segment were not taken. Transect bearings and lengths are given in Table SC010-31. Other transect parameters can be derived from Figures SC010-5, 6 and 7 and Table SC010-31.

Thirty-one transects were systematically placed on Puffin Rock spaced 20 to 30 m apart (Fig. SC010-5). Since the islet's lower slopes are all inaccessible rock cliffs, locations of transects were established from a base line measured around the upper edge of steep perimeter slopes. A compass bearing was set directly downslope and the transect was run from the bottom edge of the vegetation above the cliffs along the compass bearing back to the established point on the base line, and beyond into the interior of the islet until no more puffin burrows were encountered. Transects 1-18 and 22-24 were begun from the east side and run in a westerly direction; transects 19-21 and 25-31 were begun from the west side and run in an easterly direction.

Nine transects were run in accessible areas on the east slope of the main island. Two of those were run on the west side of the extreme south end of the east slope, in two small nesting areas. The remaining seven transects were placed at intervals along the slope from the south to the north end where the terrain permitted (Fig. SC010-6). Three transects were run on the west side of the northeast bay (Fig. SC010-7), but no transects were run on the west side due to lack of time.

In three experimental plots, toothpicks were placed at burrow entrances to compare the reliability of this method in relation to direct examination of burrow contents.

1984: Eleven transects spaced 50 m apart were run through Rhinoceros Auklet colony area in the south bay (Fig. SC010-3; Table SC010-1). Thirty-one 5x5 m quadrats were surveyed at 40 m intervals along those transects. Six permanent plots for Rhinoceros Auklets and four for Tufted Puffins were established.

Table SC010-1. Transect parameters on Triangle Island in 1984.

Transect	Bearing (°)	Total length (m)	Elevation Begin. (m)	Elevation End (m)	Average slope (°)	Range of slopes (°)
1	40	60	5	35	30	18-40
2	28	189	45	94	25	21-30
3	72	31	4	28	50	48-53
4	52	100	4	60	44	40-48
5	54	43	4	28	40	38-42
6	52	195	3	115	40	36-42
7	42	45	2	15	20	4-35
8	18	85	2	33	35	25-44
9	9	173	2	90	36	23-45
10	340	5	2	5	8	8
11	344	5	3	6	35	35

1989: A total of 2,164 quadrats, 2x2 m, were surveyed along 138 transects. Perimeter transects were spaced 50 m apart with surveyed plots at 5 m intervals. Across the top of the island, parallel transects were spaced 50 m apart through all areas of medium or high density burrowing by Cassin's Auklets. Every second transect (ie., at 100 m intervals) was run across the entire width of the island through lower density areas (Table SC010-2, Fig. SC010-2). Quadrats were surveyed at 5m intervals in medium and high density areas, and at 20 m intervals through low density sections.

To obtain an occupancy rate for Cassin's Auklets, we determined the contents of five burrows in every 40th plot surveyed. If there were less than five burrows within a plot, burrows from the immediate vicinity were used. If burrows were very sparse in an area, we selected the next plot with sufficient burrows in the vicinity to obtain a sample of five.

We explored Rhinoceros Auklet burrows, when they occurred, in the same plots used for Cassin's Auklet, but also supplemented the sample with three plots of six burrows each chosen at random along transects 23, 25 and 27. Burrows were also examined in areas where we wanted to verify species identification.

To determine an occupancy rate for Tufted Puffins, we examined every burrow in plots on Puffin Rock and in most plots on the main island. We did not examine burrows in a few plots due to time constraints.

Fifteen permanent plots were established for Cassin's Auklets, and plots established in 1984 for Rhinoceros Auklets and Tufted Puffins were resurveyed. Plots were purposefully placed in main colony areas throughout the island.

Photographic counts of murres were conducted, and total counts were made in accessible areas for all other surface nesting species.

Table SC010-2. Transect parameters on Triangle Island in 1989.

Transect	Bearing (°)	Total length (m)	Elevation Beg. (m)	Elevation End (m)	Elevation Max (m)	Average slope (°)	Range of slopes (°)
Side transects begun from shore edge of vegetation							
1	287	37.5	2	27	27	42	38-46
2	225	178	1	82	82	30	0-51
3	214	155	1	62	62	35	0-45
4	180	98.5	2	66	66	44	14-55
5	183	57	2	27	27	44	26-53
6	183	63.5	1	44	44	44	28-56
7	213	18.1	2	13	13	42	42-43
8	215	25	2	17	17	34	16-43
9	216	110	2	75	75	42	24-56
10	247	97.7	1	56	56	35	0-60
11	286	20	3	15	15	39	30-45
12	278	60.5	4	41	41	39	35-45
13	282	31	20	37	37	42	40-45
14	305	64	6	48	48	45	37-55
15	290	35.8	7	26	26	37	25-50
16	310	18	5	16	16	43	32-54
17	294	12	5	13	13	41	23-60
18	135	25.1	15	22	22	50	47-52
19	130	67.5	8	49	49	47	40-58
20	89	18	5	15	15	33	15-43
21	80	16.7	4	16	16	48	46-50
22	70	141.5	4	99	99	48	30-70
23	61	88.5	4	62	62	41	31-56
24	60	182.3	3	116	116	44	30-54
25	53	204	3	117	117	38	2-60
26	33	15	2	6	6	9	5-12
27	15	82.5	2	44	44	35	5-51
28	1	203	2	90	90	35	11-49
29	340	51	2	34	34	43	35-52
30	345	22	3	17	17	44	30-56
31	344	22	3	16	16	40	38-44
32	344	10	3	10	10	44	37-50
33	347	30	3	24	24	45	30-55
34	356	55	3	38	38	44	38-58
35	344	16.8	3	13	13	36	36
36	335	16.8	3	15	15	52	46-57
37	340	17	3	13	13	42	36-48
38	338	53.3	3	36	36	43	40-48
39	341	6	3	6	6	39	38-40
40	318	9	3	9	9	45	40-49
41	335	15.3	3	10	10	30	14-40
42	106	37	3	27	27	40	25-50
43	104	74	4	53	53	40	24-54
44	107	120	4	81	81	43	25-59
45	88	208	3	125	125	40	1-65
46	85	265	3	155	155	39	14-77
47	66	240	4	140	140	40	2-63
48	59	22.7	3	15	15	36	28-45
49	60	182	3	112	112	43	28-58
50	38	6.2	5	8	8	39	39
51	21	40.1	5	33	33	45	35-58

cont'd

Table SC010-2. (cont'd)

Transect	Bearing (°)	Total length (m)	Elevation Beg. (m)	Elevation End (m)	Elevation Max (m)	Average slope (°)	Range of slopes (°)
52	12	37	5	30	30	49	42-59
53	81	30	15	34	34	42	28-49
54	138	94.4	2	70	70	46	37-62
55	128	60	2	32	32	32	7-52
56	124	100.8	3	56	56	35	6-67
57	134	95	4	57	57	39	0-63
58	112	106.5	3	64	64	36	0-49
59	93	73.3	2	44	44	39	8-53
60	75	10	4	9	9	26	21-30
61	63	13.8	4	10	10	35	35
62	108	62.5	6	46	46	46	40-52
63	204	79	1	51	51	43	31-64
64	209	27.4	1	17	17	36	29-46
65	216	29.7	1	19	19	36	32-42
66	204	29	1	19	19	41	31-56
Side transects begun higher on slope above steep shore sections							
67	270	120	15	90	90	43	31-73
68	270	160	15	120	120	49	37-65
69	260	107	80	132	132	31	19-42
70	250	140	30	116	116	45	26-68
71	62	103	35	100	100	41	30-55
72	270	70	65	101	101	34	27-43
73	90	47	88	70	88	33	11-40
74	90	17	84	69	84	45	40-48
75	270	33.1	55	85	85	47	40-65
76	270	30	50	75	75	43	33-52
77	180	80	186	128	186	43	35-54
Top of main island							
T-1	90	35.6	50	49	51	22	20-25
T-2	90	54	32	31	32	20	0-28
T-3	270	133	75	47	75	25	7-40
T-4	90	114	67	79	79	30	20-40
T-5	270	92	89	86	89	27	15-35
T-6	90	73.2	96	93	96	27	20-31
T-7	270	93.2	101	108	108	19	10-25
T-8	90	98.8	118	114	120	19	9-33
T-9	270	72.8	136	125	136	17	10-23
T-10	270	32	142	140	142	10	7-23
T-11	270	7	142	142	142	6	1-11
T-12	270	7	138	138	138	15	10-20
T-13	180	102	135	139	139	10	8-12
T-14	180	144	121	125	130	22	15-27
T-15	0	124	112	110	117	17	11-26
T-16N	180	7	92	94	94	23	21-25
T-16S	0	12	103	104	104	18	15-22
T-17	180	148.5	73	91	93	18	11-30
T-18N	180	67	66	66	67	33	10-65
T-18S	0	32	83	79	83	15	8-31
T-19	0	137	79	78	80	17	7-24
T-20N	180	22	94	95	95	21	19-23
T-20S	0	12	90	92	92	16	12-19
T-21	180	87	110	109	115	20	16-29
T-22N	180	2	125	125	125	25	25

cont'd

Table SC010-2. (cont'd)

Transect	Bearing (°)	Total length (m)	Elevation Beg. (m)	Elevation End (m)	Elevation Max (m)	Average slope (°)	Range of slopes (°)
T-22S	0	37	126	130	130	19	11-25
T-23	0	162	145	150	152	28	20-35
T-24	0	32	165	170	170	20	15-22
T-25	0	27	181	183	183	15	10-23
T-26	0	22	192	190	192	25	15-32
T-27	0	22	186	182	186	18	13-23
T-28	0	12	181	180	181	21	19-24
T-29E	90	80	188	165	188	21	18-25
T-29W	90	247	143	188	188	19	3-33
T-30	90	122	138	157	157	23	9-51
T-31E	90	80	178	160	178	19	5-29
T-31W	270	333.5	178	120	178	26	10-50
T-32C	270	37	174	160	174	24	14-33
T-32W	90	117	110	109	110	29	11-38
T-33E	90	260	166	84	166	26	11-80
T-33W	270	482	166	115	166	24	8-40
T-34E	270	22	70	77	77	24	21-30
T-34C	270	152	135	133	159	16	4-30
T-34W	90	27	94	88	94	24	21-28
T-35E	90	206	159	88	159	23	14-33
T-35W	270	470	159	70	159	21	4-49
T-36E	270	270	99	138	157	20	0-33
T-36W	90	52	55	65	65	16	13-21
T-37E	90	128	157	120	157	18	1-26
T-37W	270	372.5	157	60	157	22	0-36
T-38E	270	107	127	133	154	21	14-28
T-38W	90	27	65	68	68	19	15-25
T-39	270	403.5	132	59	148	21	5-33
T-40E	90	119.5	127	135	145	15	6-22
T-40W	90	12	40	42	42	18	15-25
T-41	270	406	120	25	131	22	10-34
T-42	270	42	90	97	97	20	17-24
T-43	180	29.6	31	25	31	23	10-31
T-44	180	42	22	36	36	20	15-27
T-45	180	27	50	52	52	20	18-21
T-46	180	17	56	64	64	35	24-40
T-47	180	12	75	80	80	28	25-30
T-48	180	17	71	79	79	30	22-42
T-49	180	87	60	89	89	27	21-40
T-50	180	57	35	54	54	28	20-45
T-51	180	37	55	70	70	27	23-30
T-52	180	57	65	92	92	40	18-64
T-53	180	23.2	50	76	76	30	21-40
Puffin Rock							
P-1	109	33.5	55	50	57	20	1-36
P-1	109	10.5	68	66	68	21	18-24
P-3E	289	39	67	66	71	18	1-33
P-3W	109	61.5	50	44	57	20	0-45
P-4	109	145	60	52	72	17	1-58
P-5	289	130.5	50	78	83	20	16-26
P-6	109	14.3	91	88	91	12	6-17
P-7	260	22	57	71	71	41	36-46
P-8	260	25	3	18	18	37	32-59

Nesting species:

Fork-tailed Storm-Petrel: Storm-petrels were nesting sparsely and sporadically on Triangle Island. Fork-tailed Storm-Petrels were regularly heard calling at night around the south bay during all visits, though the frequency of their calls was less than those of Leach's Storm-Petrels. The only other evidence of breeding found was one bird heard calling from a burrow on the south end of Puffin Rock on 20 June 1989. We estimated 100 pairs of Fork-tailed Storm-Petrels breeding on Triangle Island.

Leach's Storm-Petrel: Leach's Storm-Petrels were regularly heard calling at night from our camp in the south bay during all visits. In 1982, two adults incubating eggs were found in burrows: one on 11 July mixed with Tufted Puffin burrows on the east slope of Puffin Rock in Tufted Hairgrass and short salmonberry habitat along transect 3; and one on 27 July on the east slope of Triangle Island in a patch of ferns just below transect 40. In the over 2100 plots surveyed along transects in 1989, we found only one burrow that was petrel sized, located in plot 18 on transect 5 on Puffin Rock. One cold petrel egg was discovered in a small burrow in Tufted Puffin permanent plot 4 on 17 August 1989.

We made no attempt to calculate nesting populations of storm-petrels. Judging from nocturnal activity and breeding evidence found in various locations, we estimated the breeding population of Leach's Storm-Petrels to be 200 pairs.

Pelagic Cormorant: Numbers and locations (Fig. SC010-4) of nesting cormorants varied between years, and within single seasons.

1982: No overall count was completed in 1982. Nesting was observed on Puffin Rock on the mid-east side cliffs and on the amphitheatre of cliffs between the west side of the south point and the south side of the west point. Records made give some information about breeding chronology: 1 nest with 2 eggs on 10 July; 1 nest with 3 eggs on 18 July; 1 nest with 2 young (12 cm) on 19 July; 1 nest with 1 young (40 cm, beginning to feather) on 19 July; and 1 nest with 2 well-feathered young on 23 July. Nesting was also recorded on "Sentinel Pinnacle" off the northeast corner of the main island, where 64 nests were counted on 9 July, and on the "Hook" and the cliffs south of it on the east slope of the island.

1984: In 1984, few cormorants were successfully nesting. A maximum of 124 adults in breeding plumage were counted around the island on a census taken 12 July. Of these, 33 were sitting on nests, the rest were merely roosting. On "Sentinel Pinnacle", 17 birds were sitting on nests, with six adults and one immature roosting. It was possible to inspect three nests on the west side of the pinnacle: two were empty and one had one egg. Seven cormorants were on nests and 31 were roosting on the "North Pinnacles", and nine birds were on nests, with 24 roosting, on "Strata Rock" on the northeast corner of the island.

Other nesting sites were abandoned. There were no birds sitting on nesting cliffs on Puffin Rock, although 18 dilapidated nests were seen. There was no guano on the cliffs (6, 9, 12, 22 July). On 12 July, one bird was observed carrying nesting material. A group of breeding adults (maximum 29) was regularly observed roosting on tidal rocks at the southeast corner of Puffin Rock. On the "Hook" on the mid-east side of the island, we counted 21 nests on 14 July, but no cormorants were in the vicinity. There was guano on the nests and cliffs, indicating recent activity. Ten depredated eggs were found below the nests.

1985: A total of 144 nests were counted in 1985, all with adults sitting on them. Most nests were on Puffin Rock: 21 on the south end of the east side counted on 11 July; 104 on the west side of the south point, including the amphitheatre cliffs, counted on 16 July; and 5 on the south side of the west point and 4 on the west side of the west point counted on 19 July. The only other visible nesting area in 1985 was on the south side of the "Impasse" in the northeast bay, where 10 nests were counted on 20 July. There were no nests on "Sentinel Pinnacle", "North Pinnacles", "Strata Rock", the "Hook" or the cliffs around the southeast point.

1989: More cormorants were nesting in 1989 than in previous years. A total of 433 active nests were tallied. An additional 45 nests were built early in the season, but were later abandoned (Table SC010-3).

Table SC010-3. Number of Pelagic Cormorant nests on Triangle Island in 1989.

Location	Date	Attended nests	Abandoned nests	Comments
Puffin Rock:				
East side:				
- middle crevice	6 Aug	12		
- S of crevice	6 Aug	3		
- above S sea-cave	12 Aug	89	8	
- S of sea-cave	6 Aug	8	3	
West side:				
- S end	6 Aug	12	1	
- Amphitheatre	6 Aug	0	14	Active on 20 June
- S side W point	6 Aug	22		
- N of W point	6 Aug	2		
North Pinnacles	12 Jul	4		
Strata Rock	7 Aug	0	19	Active on 7 June
S side of Impasse	9 Jun	6		
The Hook	8 Jun	35		
S of the Hook	8 Jun	68		
E side SE point	5 Jul	108		
W side SE point	5 Jul	64		
Total		433	45	

Nesting birds were disturbed as little as possible and few nest contents were determined. Single nests with two eggs and three eggs each were observed on Puffin Rock on 20 June. Most nests held large young by early August.

Increased numbers of roosting Pelagic Cormorants were noted in early August 1989. We counted 330 roosting birds around Triangle Island on 10 August: 68 at the southeast corner of Puffin Rock; 180 on the North Pinnacles; and 82 on the rocks on the west side of Castle Rock. Most birds were in non-breeding plumage.

Black Oystercatcher: Observations of oystercatchers were made during each visit, but 1989 was the only year we were present during their incubation period and were able to conduct a complete census.

1982: We regularly observed a roosting flock in the south bay. A maximum of 23 were counted in the flock on 19 July at 1100 h. Nests were found on the west side earlier in the season by A. Vallee.

1984: We identified four nesting sites in 1984. Three empty scrapes were located: in the south corner of the west bay; the middle of the north beach; and on the mid-east side. Two newly hatched chicks were seen at the south end of the northwest bay on 15 July. Two excited adults were present at all four sites. A maximum of 19 birds were seen roosting in the south bay on 23 July.

1985: Two adults with three large young were observed near the east end of the south bay on 13 July, and one large young was encountered on the east side near the sea-cave on 20 July. We found two other scrapes on the south beach, and recorded a maximum of 12 roosting birds on 21 July.

1989: We located 23 oystercatcher nests, plus one territory where we could not find the nest, around the perimeter of Triangle Island on 6 and 7 June 1989 (Fig. SC010-4). An additional nest site was discovered on 9 July, giving a total estimate of 25 nesting pairs. Nests were located along upper edges of beach areas. Contents of the 23 nests inspected on 6 and 7 June were:

Empty	1E	2E	3E	1E2Y
1	2	8	10	2

The nest found on 9 July contained two eggs. One egg that was accidentally stepped on was very fresh. Many nests were just depressions in the beach, but in more rocky areas, nests were made of collections of rock chips and shells.

We made observations of roosting flocks of oystercatchers during our stay in 1989. The size of the flock that frequented the south bay grew from five birds on 9 June to 41 birds on 17 June (12 on 10 June; 20 on 14 June; 26 on 15 June; 34 on 22 June; 25 on 27 June). In late July and early August, we observed a flock of up to 31 birds roosting on the outer southwest corner of Puffin Rock (15 on 29 July; 24 on 4 August; 31 on 6 August). We suspected they were the same birds observed earlier in the south bay. Four birds were sighted on Castle Rock on 6 August.

Glaucous-winged Gull: In all years, nesting concentrations of Glaucous-winged Gulls occurred on Puffin Rock, the adjacent southwest corner of the main island, and around the southeast point of the island. Smaller numbers were observed on isolated, offshore rocks, and on rocky points around the rest of the island (Fig. SC010-4). Nests were located on cliff ledges, rocky ridges and throughout much of the Tufted Hairgrass slopes around Puffin Rock, and in rocky areas and on the edges of grassy slopes in other areas.

1982: During the period of the 1982 census, most eggs had hatched (large downy young were found hiding under grass tussocks on 10 July) and by 31 July gull chicks were fledging. No census was attempted.

1984: Gulls experienced almost total nesting failure in 1984. Pairs of adults were continually standing on territories, but few were sitting on or attending nests. Of 81 nests inspected in different parts of the island, only three contained eggs, none full clutches: 2 with 1 egg on 14 July and 1 with 2 eggs on 6 July. We suspect those were attempts at relaying. Many broken or depredated eggshells were found. No young or signs of young, such as hatched eggshells, trampled nests or uneaten fish were observed.

Table SC010-4. Counts of Glaucous-winged Gulls on territories on Triangle Island in 1984.

Puffin Rock:	294 plus 100 estimated
Southwest corner:	13
Sentinel Pinnacle:	2
North Pinnacles:	6
Strata Rock:	6
Cliff- tops along east side:	20
Southeast point and islets:	34 plus 200 estimated
Total:	675

From counts of adults on territories (Table SC010-4), we estimated a total breeding population of 337 pairs. In addition to birds standing on territories, there were a number of adults at three regular roost sites in the south bay: on the west side of the southeast point

(maximum of 81 counted on 12 July); in the middle of the south bay (maximum of 128 counted on 28 July); and at the base of Puffin Rock (maximum of 61 counted on 25 July). The maximum single count including all three sites was 195 made on 12 July. Gulls moved among sites, especially when disturbed by passing eagles. Very few immature gulls were observed at those roosts. The maximum was eight on 28 July.

1985: We did not estimate the total nesting population of gulls in 1985, but the contents of a number of nests on Puffin Rock and the southeast point were determined. Sixty-five nests were inspected between 16 and 20 July with a total of 55 eggs and 36 young (Table SC010-5).

Table SC010-5. Contents of Glaucous-winged Gull nests examined on Triangle Island in 1985.

Date	Empty	1E	2E	3E	2E1Y	1E2Y	1E1Y	3Y	2Y	1Y
16 July	6	2	1	3		1	1			1
19 July	10	3	6	7	1		1	1	5	6
20 July	4						1	1	3	1
Total	20	5	7	10	1	1	3	2	8	8

Gulls were using the same roost sites in the south bay as they were in 1984. There were a total of 164 adults present at the three sites on 15 July. As in other years few immature gulls were seen. One was observed on 19 July, and three immatures and two subadults were present on 21 July.

1989: In 1989, all nests were counted in accessible areas and numbers of adults on territories were counted in other locations (Table SC010-6). We estimated a total nesting population of 577 pairs. Nests were made of grass in all areas. The first young were observed on 20 June, and most had hatched by early July.

Glaucous-winged / Western Gull hybrid: On 5 July 1989, we observed a pair of hybrid gulls defending a territory along the east side of Triangle Island, just north of the southeast corner. Their wing-tips were black on top and dark grey below, and had a single white spot. They had dark irises. One of the pair was slightly smaller than Glaucous-winged Gulls in the area. The pair was very defensive, continually calling and swooping at us while we were in the vicinity of the nest. They returned directly to the nest site when we moved away. There was one small young and a recently hatched eggshell at the well worn nest. We watched the birds for about 40 minutes. Photos of the adults and chick were taken.

Table SC010-6. Glaucous-winged Gull nests counted on Triangle Island in 1989.

Location	Date	Sta	Emp	1E	2E	3E	2E1Y	1E2Y	1E1Y	3Y	2Y	1Y	SusY	Ad	Est	Total
Puffin Rk:																
- Top	20 Jun	5	8	8	45	148				1						215
- W face	20 Jun													56	28	28
- E face	6 Jul													40	20	20
- Base, E side	6 Jul		7		3	4						1				15
- N end	6 Jul		1			2				1				32	12	16
SW ridge	6 Jul													44	22	22
Land's End	7 Jun					1								4	1	2
N Pinnacles	7 Jun													6	3	3
Strata Rock	7 Jun													24	12	12
N of Impasse	9 Jul									2		1	1		2	6
S side Impasse	6 Jun			1	1	1										3
E side:																
- N of Arch	6 Jun			3	2	5										10
- S of Arch:																
- along shore	5 Jul		1					1		1	4	4	1		4	16
- above cliffs	5 Jul													32	30	30
Sea-lion shelf	5 Jul													44	22	22
SE point:																
- Main island	5 Jul		2	1	1	1		1	1	1	3				14	25
- SE rock	5 Jul					1				1						2
- SW rock	5 Jul					2	1			3	1	2			7	16
- S. of SW rock	5 Jul		1							2	1					4
- Spire	5 Jul														9	9
Outer S rocks:																
- small N	6 Aug													37	19	19
- outer S	6 Aug													125	63	63
Castle Rock	6 Aug													18	9	9
													Total			577

Common Murre: 1982: We could see murres nesting only on Puffin Rock and the rock off its west side. Total counts of all visible birds on the nesting cliffs were made on 10 July from 1400h to 1800h. A total of 4,910 birds were counted (Table SC010-7).

A number of birds could not be seen to be counted, especially on the west side cliffs towards the north end of Puffin Rock, so the above count would be less than the actual total. Birds were incubating eggs. Two eggs were found on a grassy shelf on 19 July. No young were seen during our visit. At the time this count was made there were as many, if not more birds on the water off the west side of Puffin Rock as on the nesting cliffs.

Table SC010-7. Common Murres counted on visible nesting sites on Puffin Rock in 1982. Site numbers assigned in 1989 are listed in brackets.

E crevice (1)	20
W side of S pt. (4-8)	1024
S side of W pt. (13,14)	1140
W side, N of W pt.: (15)	648
(16,17)	206
(18)	29
Murre Rock (22,25,top)	1843
Total	4910

1984: No murres were nesting in 1984. Broken or depredated eggshells were found on Puffin Rock, but no birds were observed incubating eggs. All visible nesting slopes were empty, though the murres would fly up and stand on the slopes for brief periods. This behavior was observed on Puffin Rock on 6 July, on the islet off the southeast point on 13 July, and on Castle Rock on 13 and 15 July. Groups would gather on nesting slopes - calling, copulating, and head nodding - and then disperse en masse.

Birds clustered in tight rafts on the water around those three locations. An estimated total of 12,000 were present most of the time. Maximum numbers recorded were 10,000 around Puffin Rock on 6 July, and 1500 around the southeast point and 1500 around the east rock on 15 July. Murres dispersed to the north for the evening. On 15 July, 7,030 were counted flying north in flocks of 5 - 150 birds between 2130 and 2200 h. On 21 July, more than 5,000 flew north between 2145 and 2230 h.

Table SC010-8. Counts of Common Murres on visible nesting sites on Triangle Island in 1985. Site numbers assigned in 1989 are listed in brackets.

Location	Date-time	Count
Puffin Rock		
- E crevice (1)	19 Jul-1030h	13
- W side of S pt. (4)	16 Jul-1730h	42
(7)	16 Jul-1730h	430
(8)	16 Jul-1730h	800
(9)	16 Jul-1730h	61
(11)	16 Jul-1730h	1
- S side of W pt. (12)	19 Jul-1230h	24
(13,14)	19 Jul-1230h	540
- W. side, N of W pt. (15)	16 Jul-1800h	400
(16)	16 Jul-1800h	32
(17)	16 Jul-1800h	53
(19)	16 Jul-1320h	60
(20)	16 Jul-1800h	60
Murre Rock (22,25,top)	16 Jul-1800h	740
Castle Rock (27,29,30)	17 Jul-1800h	500
Southeast pt. (36)	9 Jul-1100h	200
	Total	3956

1985: Murres were successfully nesting in 1985. We counted 3,256 Common Murres on nesting slopes and ledges around Puffin Rock, and estimated 700 on Castle Rock and the southeast islet (Table SC010-8). We examined Castle Rock from the northeast corner of the main island, and viewed the southeast islet from helicopter.

Our stay in 1985 was confined to the incubation period. We saw five eggs being incubated on 19 July. No sign of hatching was observed.

1989: Detailed results of studies on murres in 1989 are reported elsewhere (Rodway 1990). A summary of population estimates is presented here.

We identified and photographed 37 sites frequented by murres around Triangle Island (Table SC010-9). The mean number of birds counted from photographs of all those sites was 5,839 ± 87 (Table SC010-10).

By comparing hourly counts by telescope to counts from photographs made on the study plot, we calculated a mean ratio of 1.44 ± 0.02. We used that ratio to adjust the estimate of total numbers of murres derived from photographic counts.

From the top of Puffin Rock, we took detailed photographs of areas that were difficult or impossible to view from the water (Table SC010-11). The top of Murre Rock is not visible, and its southeast side (site 22) can only be viewed obliquely from the water. Counts from photographs were adjusted to counts at 1800 h, according to attendance patterns determined on the study plot, and then compared to mean photo-counts from the water. Photographic counts from land of the six sites listed in Table SC010-11, exceeded mean counts from the water by 1535. Corrected counts for all sites gave a total population estimate of 9,943 ± 202 birds.

Though total counts in 1989 were higher than previous counts, the apparent increase was due largely to more complete coverage of the colony. Comparable counts at specific sites in 1982, 1985 and 1989 were highest in 1982 and lowest in 1985 (Rodway 1990).

Murres successfully hatched young at most locations around Puffin Rock, but were unsuccessful at almost all sites on the east side of the island, including Castle Rock. At 12 sites (1, 3, 9, 27-32, and 35-37) birds were absent from the nesting ledges during at least part of the survey. At 1200 h on 6 August, there were no murres on ledges or on the water in the vicinity of sites 27-32 and 35-37. We explored Castle Rock at that time and found 119 depredated eggshells gathered into piles in the middle of the rock, likely by Glaucous-winged Gulls. The only sites on the east side of the island at which breeding birds remained tenaciously on territories were 26, 33, and 34. Murres would gather at unsuccessful sites during the late afternoon, and large numbers were regularly present at 1800-2000 h when we conducted photographic counts. Those birds were easily disturbed and frequently flew off nesting ledges at our approach, even when we were more than half a kilometer away.

1989 Breeding population: The breeding population of Common Murres on Triangle Island in 1989 was calculated to be 4,077 ± 83 pairs (Table SC010-12). An estimate of successfully nesting birds was derived by excluding birds at sites that were abandoned at some time during the surveys. Excluding those locations gave an estimate of 3,372 ± 49 pairs that successfully hatched young in 1989.

Hatching chronolgy: Chicks had just begun to hatch when we began intensive observations, and 76.7% of hatching occurred during the study period between 2 and 17 August. The peak of hatching, and the median hatch date, occurred between 5 and 8 August when 36.2% of chicks hatched. No chicks were observed fledging during the study period.

Table SC010-9. Location of sites used for photographic counts of murres on Triangle Island in 1989.

Site number	Location
Puffin Rock	
1	Crevice on mid-east side.
2	Ridge and small, high cave south of site 1.
3	Edge of grass at upper south end of east side.
4	Ledge on upper south end of west side.
5	Ledge just north and below site 4.
6	SE side of low rock just north of southern sea-cave.
7	West side of low rock just north of southern sea-cave.
8	Lower rock and ridge just south of middle sea-cave.
9	Small ledge on cliffs above middle sea-cave.
10	Low crevice on north edge of middle sea-cave.
11	Small, grassy ridge above, and just north of middle sea-cave.
12	Ledges on south face of west point.
13	Eastern of two groups on upper southwest corner of west point.
14	Western of two groups on upper southwest corner of west point.
15	Edge of grass at south end of west side of west point.
16	Upper, grassy nose north of site 15.
17	Ledges at edge of grass below site 16.
18	Ledges on cliffs south of northern sea-cave.
19	Low cliff just south of northern sea-cave.
20	Low cliff just north of northern sea-cave.
21	Low cliff near north end of Puffin Rock; opposite Murre Rock.
Murre Rock	
22	Southeast side.
23	South end of west side.
24	North end of west side.
25	Northeast side.
Castle Rock	
26	West side of southwest pinnacle.
27	North side of southwest pinnacle.
28	East side of southwest pinnacle.
29	West side of main rock.
30	North side of main rock.
31	East side of main rock.
Southeast point	
32	East side of east rock.
33	East side of rock just north of south end.
34	Southwest side of rock just north of south end.
35	Edge of grass on east side of south end.
36	Top, south side of south end.
37	Lower, northwest corner of south end.

Table SC010-10. Photographic counts of Common Murres on Triangle Island in 1989. Photos were taken between 1800-2000 h except for the additional count conducted at noon on 6 August. The noon count was not included in the mean. Daily totals are listed for the most complete counts.

Site number	Date															
	27 Jul	29 Jul	1 Aug	4 Aug	6 Aug	10 Aug	12 Aug	13 Aug	15 Aug	16 Aug	17 Aug	Mean	S.D.	S.E.	N	6 Aug (noon)
1	39	49	43	41	39	44	0	2	39	45	33	34	16	5	11	8
2	3	5	14	3	8	9	3	2	10	18	18	8	6	2	11	1
3	0	46	27	0	2	0	0	0	3	2	0	7	14	5	11	0
4	42	29	30	34	21	23	x	x	23	26	19	27	7	2	9	10
5	36	34	26	39	39	44	x	35	39	41	39	37	5	2	10	32
6	182	202	202	186	145	134	x	156	161	151	165	168	22	7	10	110
7	254	349	336	362	355	365	262	x	317	303	399	330	44	15	10	307
8	393	541	559	497	523	x	x	513	487	486	456	495	46	16	9	392
9	12	0	14	19	11	11	12	17	24	16	13	14	6	2	11	14
10	-	-	30	30	-	29	-	x	20	34	32	29	4	2	6	19
11	-	-	-	-	-	-	-	-	23	22	14	20	4	3	3	18
12	18	47	56	41	46	29	x	40	41	36	41	40	10	3	10	16
13	365	404	297	382	359	330	x	409	421	374	382	372	36	12	10	268
14	517	524	440	500	515	592	x	510	561	584	584	533	45	15	10	446
15	470	488	fog	466	329	x	x	x	406	382	401	420	53	22	7	323
16	78	96	fog	111	88	x	x	x	90	82	103	93	11	4	7	46
17	165	155	fog	176	133	x	x	x	132	156	132	150	16	7	7	84
18	139	168	fog	168	111	x	152	120	119	144	128	139	20	7	9	49
19	179	156	fog	149	176	139	127	150	137	135	148	150	16	5	10	99
20	57	53	fog	55	58	x	x	66	59	52	53	57	4	2	8	42
21	179	184	fog	193	214	x	194	x	215	196	210	198	13	5	8	163
22	165	141	fog	173	135	125	164	156	x	124	118	145	19	7	9	115
23	149	152	fog	179	189	175	174	x	x	183	165	171	13	5	8	139
24	476	547	fog	449	428	x	389	x	438	403	484	452	47	18	8	327
25	296	237	fog	187	432	184	284	x	233	237	220	257	71	25	9	200
26	63	75	fog	62	54	82	x	66	72	72	67	68	8	3	9	17
27	196	207	fog	240	250	213	x	213	199	209	194	209	14	5	8	0
28	63	46	fog	44	*	35	x	53	62	54	41	50	9	4	8	0
29	22	167	fog	38	x	x	x	162	132	159	163	120	58	24	7	0
30	0	336	fog	235	*	505	x	400	453	460	399	349	153	58	8	0
31	*	146	fog	166	*	141	x	174	150	171	148	157	12	5	7	0
32	99	1	fog	0	2	63	126	91	82	103	76	64	44	15	10	0
33	119	147	fog	204	170	136	114	129	131	150	136	144	25	8	10	34
34	134	145	fog	198	150	77	125	137	x	146	146	140	29	10	9	56
35	0	40	fog	0	0	32	38	x	25	39	46	24	18	6	9	0
36	68	144	fog	60	38	49	95	102	x	132	120	89	35	12	9	0
37	92	83	fog	159	33	x	60	135	x	47	44	82	42	16	8	0

Totals:	Maximum						Mean		Minimum
All sites	6144	5846			5964	5937	5839	87	3335
Sites that were always occupied	4874	4860			4535	4655	4646	52	3326

*: murres flew off at our approach.
x: photo ruined by shutter problem.
-: photograph not taken.

Table SC010-11. Counts from land of murres not visible from the water during photographic surveys on Triangle Island in 1989. Numbers were adjusted to 1800 h using mean proportions determined during studies of attendance patterns (Rodway 1990). Maximum and minimum figures are from Table SC010-10.

Site	Date	Time	No. of birds	adjusted to 1800h	amount > mean
6	19 Aug	1220	256	279	111
13	19 Aug	1220	426	464	92
15	15 Aug	1620	523	585	165
22	15 Aug	1620	778	870	725
Top of Murre Rk.	15 Aug	1620	263	294	294
25	15 Aug	1620	425	425	148
Total to add to mean					1535
Total to add to minimum (X 3335/5839)					877
Total to add to maximum (X 6144/5839)					1615

Table SC010-12. Calculation of Common Murre breeding population on Triangle Island in 1989.

Total counts from photographs of murres at breeding sites around Triangle Island.

Mean	S.E.	Minimum	Maximum
5839	87	3335	6144

Total counts adjusted by ratio of telescope to photograph counts on study plot.

Mean	S.E.	Minimum	Maximum
8408	171	4802	8847

Total adjusted counts plus birds counted from land that were not visible from the water.

Mean	S.E.	Minimum	Maximum
9943	202	5679	10462

Ratio of breeding sites to total birds counted on study sites (*k*).

Mean	Minimum	Maximum
0.41	0.53	0.39

1989 Breeding population estimate (*k* x total birds at breeding sites).

Mean	S.E.	Minimum	Maximum
4077	83 pairs	3010 pairs	4080 pairs

Thick-billed Murre: Thick-billed Murres were first documented nesting on Triangle Island in 1981 (Vallée and Cannings 1983). They were nesting on Puffin Rock in association with Common Murres. In 1982, we made a total count of 70 on 10 July: 68 on the nesting cliffs on the west side of Puffin Rock, north of the west point (labelled site 17 in 1989), and two on the mid-east cliffs (site 1 in 1989). Birds were incubating eggs. No young were seen during our visit.

In 1984, at least 50 Thick-billed Murres were observed flying around Puffin Rock and landing in association with Common Murres on the west side. As with Common Murres, none were successfully nesting. A few birds were seen on the west side of Puffin Rock that were suspected to be Common Murre/Thick-billed Murre hybrids (I. Jones pers. comm.)

Thirty-four Thick-billed Murres were counted mixed with 53 Common Murres at site 17 at 1800 h on 16 July 1985. No eggs were seen, but birds appeared to be incubating.

In 1989, the maximum number counted was 41 at 1645 h on 31 July. One egg was seen as a pair changed incubation duties. Only seven of the birds were sitting as if incubating, the rest were standing. There was no sign of chicks. Most of the birds were at site 17 as in past years, but four were counted on the small ridge above (site 16). On 2 August at 1130 h, one Thick-billed Murre was perched on the pinnacle at the top of our study plot. There was also an incubating bird on section E of the study plot that may have been a hybrid. It had a white stripe along the edge of the upper mandible like a Thick-billed Murre, but its plumage was dusky-brown like a Common Murre (Birkhead *et al.* 1986).

Pigeon Guillemot: 1982: Two nesting sites were identified in 1982: at the base of the northeast corner of Puffin rock, where a maximum of 61 birds were counted on 18 July at 1130 h; and along the east side of the southeast point, where a maximum of 25 birds were counted on 21 July at 1300 h. No nests were actually located but birds were seen flying out of the clusters of large boulders in both areas.

1984: All perimeter areas were censused for guillemots in 1984. The maximum total observed around the island was 241 birds (Table SC010-13).

Table SC010-13 Numbers of Pigeon Guillemots counted around Triangle Island in 1984.

Location	Date	Time	Number
NE corner of Puffin Rk.	25 July	1030	49
Seal Corner	12 July	1300	26
NE bay, S of Impasse	14 July	1150	43
E side N of sea-cave	14 July	1100	47
E side of SE pt.	14 July	1000	67
SE pt.	14 July	0940	9
Total			241

No nests were located though two depredated eggs were found on the east side of the island. Adults were observed flying out of the rock jumbles just north of the sea-cave on the east side, and from the area north of the Impasse. We did not spend much time looking for nests, and did not determine if guillemots were breeding successfully in 1984.

1985: Similar numbers of guillemots were observed at specific sites in 1985 as in 1984 (Table SC010-14). Two additional nesting locations were discovered: at Land's End, and at the NE corner of the island. Birds were seen flying out of rock piles and crevices at those locations. Counts along the east side and around the southeast point were incomplete in 1985, so overall totals are not comparable.

Table SC010-14 Numbers of Pigeon Guillemots counted around Triangle Island in 1985.

Location	Date	Time	Number
NE corner of Puffin Rk.	16 July	1300	49
Seal Corner	17 July	1120	17
Land's End	17 July	1200	36
NE corner Strata Rk.	17 July	1800	4
NE bay, S of Impasse	20 July	1300	42
E side of SE pt.	20 July	1200	25+
Total			173+

The contents of five nests were determined on 20 July in the rock jumble south of the Impasse: one with one egg; two with one young; one with two young; and one with an adult sitting.

1989: Counts were made over a more extensive period in 1989, and the maximum total of 331 is likely closer to actual numbers of birds using the island than those counted in previous years (Table SC010-15). Birds were nesting at all sites identified in past years, except at Land's End. No birds were recorded there in 1989. Perhaps that site is not used every year, as 1985 was the only year they have been sighted there.

Table SC010-15 Numbers of Pigeon Guillemots counted around Triangle Island in 1989.

Location	Date	Time	Number
NE corner of Puffin Rk.	31 Jul	1045	66
Seal Corner	12 Jul	1030	26
Sentinel Rk.	9 Aug	1800	1
NE corner by Strata Rk.	7 Aug	1200	33
NE bay, S of Impasse	7 Jul	1400	27
E side, N of sea-cave	7 Jun	1030	57
E side, S of sea-cave	5 Jul	1000	70
E side of SE pt.	5 Jul	1000	35
Castle Rk.	6 Aug	1300	16
Total			331

One nest on the east side of the island that we determined the contents of held one egg on 6 June. One bird carrying a fish flew into a crevice on Castle Rock on 6 August.

Cassin's Auklet: 1982: The only areas explored thoroughly in 1982 were those in which puffins were nesting. Cassin's Auklet burrows were sparse amongst dense puffin burrows on steep Tufted Hairgrass slopes, but were abundant on upper, moderate slopes in Tufted Hairgrass, salmonberry and fern habitat where puffins were less dense or absent.

As many as 58 Cassin's Auklet burrows were found in 3x5 m plots in the course of the puffin survey. No estimates of overall burrow density or nesting populations were made.

1984: During the survey for Rhinoceros Auklets in 1984, Cassin's Auklet burrows were found along all transects on south slopes (Table SC010-16), becoming predominant at the crest of the steep slopes and continuing onto the more level interior of the island.

Table SC010-16. Numbers of Cassin's Auklet burrows in 5x5 m plots along transects in the south bay of Triangle Island in 1984.

Plot	Transect										
	1	2	3	4	5	6	7	8	9	10	12
1	23	4	3	4	1	5	5	5	3	2	3
2	3	11	9	4	1	3	0	2	9		
3		4		2		11		3	2		
4		7				7			6		
5		10				6			27		

The contents of 31 burrows determined along transects and in the Rhinoceros Auklet growth plot, give an indication of breeding chronology. All occupied burrows contained chicks or signs of recently fledged young. Fledglings were seen walking down the slopes during the nights of 9-11 July. One fledgling was found in the daytime hiding under an elderberry bush.

1985: Few observations were made of Cassin's Auklets in 1985. Three large, ready-to-fledge chicks were found in burrows on 19 and 21 July.

1989: Cassin's Auklets were the major focus of the survey in 1989. They were found nesting in virtually all accessible areas of the island, including the densest thickets of salmonberry, crabapple and salal. Two adults discovered that had hung themselves in mazes of salmonberry branches while trying to get to or leave their burrows, attested to the perverse proclivity of those birds to nest in inhospitable habitat. Within colony sampled at 5 m intervals, low, medium and high density classes were assigned to areas with average burrow densities < 2, 2-8, and > 8 burrows per plot respectively (ie., a plot with < 8 burrows may have been included in high density area if surrounding plots consistently had higher numbers).

Burrows were abundant in all open, herbaceous habitat with enough soil to support them, except where Rhinoceros Auklets or Tufted Puffins predominated. The most extensive area of high burrow density occurred in Tufted Hairgrass habitat in the west bay, but dense burrowing also occurred under tall salmonberry on Puffin Rock, in saxifrage and Wood Fern along the top ridge of the island, and in mixed Tufted Hairgrass, short salmonberry and Lady Fern in the northwest bay (Fig. SC010-2; Table SC010-17). Low density burrowing occurred under dense shrubbery across most interior slopes, and under tall Lady Fern in the northeast bay.

Most burrows occurred under grass tussocks or shrubbery (Table SC010-18). Virtually all burrows coded as under shrubbery were under salmonberry. Incidental burrows were found under salal, crabapple and elderberry. The proportion of burrows in salmonberry

(text continues on page 41)

Table SC010-17. Number of Cassin's Auklet, Rhinoceros Auklet and Tufted Puffin burrows in 2x2 m plots along transects on Triangle Island in 1989. Plots are coded according to assigned density classes: H - high; M - medium; L - low; T - top-low (plots > 5 m intervals); X - not colony. Second entrances (2nd E), starts > 15 cm long (ST>15), and starts < 15 cm long (ST<15) are also listed. An asterisk under Rhinoceros Auklets or Tufted Puffins indicates that burrows were too sporadic to map the area as colony, and plots were not included in density calculations.

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST<15	CAAU ST>15	RHAU	TUPU
Side transects from shore edge of vegetation								
1	1	X						
	2	X						
	3	X						
	4	0	L					
	5	0	L					
	6	0	L					
	7	1	L					
	8	1	L					
2	1	0	L					
	2	0	L					
	3	0	L					
	4	1	L					
	5	X						
	6	X						
	7	X						
	8	X						
	9	X						
	10	0	L					
	11	0	L					
	12	1	L		1			
	13	0	L					
	14	0	L				0	
	15	0	L				0	
	16	4	L			1	5	
	17	0	L				0	
	18	2	L				1	1
	19	1	L				1	0
	20	1	L			1	1	0
	21	4	M				1	0
	22	2	M					
	23	5	M					
	24	0	M					
	25	2	M		1			
	26	3	M			1		
	27	4	M				1	
	28	2	M				3	
	29	5	M		1	1		
3	1	2	L					
	2	0	L					
	3	0	L					
	4	0	L					
	5	0	L					
	6	0	L					
	7	0	L					
	8	1	L					
	9	0	L					
	10	4	L		1	1		
	11	0	L					
	12	2	L					
	13	2	L					
	14	1	L					
	15	1	L		1			
	16	0	L					
	17	0	L		1	1		
	18	0	L		1			
	19	4	M		1			
	20	1	M					
	21	0	M					
	22	3	M					
	23	3	M		1			
	24	0	L		1			
	25	2	L		1			
	26	1	L					
	27	1	L		2	1		
	28	1	L		1	1		
	29	2	L		1			
	30	3	M				1	
	31	5	M		1	1	1	
4	1	2	M					
	2	1	M					
	3	3	M		1			
	4	1	L					
	5	0	L					
	6	0	L					
	7	1	L			1		
	8	0	L		1	1		
	9	1	L					
	10	0	L					
	11	0	L					
	12	0	L					
	13	7	M					
	14	4	M		1			
	15	5	M			1		

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST<15	CAAU ST>15	RHAU	TUPU
	16	7	L					
	17	0	L			1		
	18	0	L				1	
	19	0	L					
	20	0	L					
5	1	0	L					
	2	0	L					
	3	1	L					
	4	3	M					
	5	2	M				1	
	6	2	M					
	7	3	M			2		
	8	3	M				1	
	9	5	M					
	10	5	M					
	11	2	M					
	12	1	L					
6	1	1	L					
	2	1	L					
	3	1	M					
	4	3	M					
	5	3	M					
	6	1	L					
	7	1	L					
	8	1	L					
	9	1	L					
	10	0	L					
	11	0	L					
	12	0	L					
	13	0	L					
	14	0	L					
	15	1	L					
	16	0	L					
	17	0	L					
	18	0	L					
	19	6	M			1		
	20	2	M					
11	1	X						
	2	X						
	3	0	M					
	4	0	M					
12	1	X						
	2	X						
	3	X						

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	4	X						
	5	X						
	6	1 L						
	7	0 L			1			
	8	X						
	9	X						
	10	X						
	11	X						
	12	X						
13	1	0 L						
	2	1 L						
	3	9 H			3	1		
	4	13 H						1
	5	7 H				1		2
	6	4 M						1
14	1	3 M			3	1		
	2	9 H			2			
	3	7 H		1	2	2		0
	4	10 H		2	4			0
	5	8 H			2			0
	6	14 H		2	2			0
	7	14 H			2			1
	8	9 H		2	5			0
	9	13 H		1	2			2
	10	7 H			4	2		2
	11	6 H			1	2		
	12	6 H			2	1		
	13	10 H						
15	1	8 H			5	1		
	2	7 H			5			
	3	13 H			1			
	4	11 H		4	2	1		
	5	9 H		4	1			
	6	14 H			2			
	7	12 H		2	4			
16	1	2 L				1		
	2	3 L			1			
	3	0 L						
17	1	1 L						
	2	4 L			1			
	3	0 L				1		
18	1	6 M						
	2	3 M						
19	1	1 M		1				
	2	5 M			2	2		
	3	8 M				2	1	
	4	8 M			3	1	0	
	5	6 M					0	
	6	6 M			1		0	
	7	7 M				1	0	
	8	10 M				2	3	
	9	0 M					1	
	10	14 H		1	2		0	0
	11	7 H				1	0	0
	12	8 H				2	1	0
	13	7 H					0	3
20	1	6 M						
	2	1 M						
	3	4 M			4	1	2	
	4	5 M		1	1		0	
21	1	0 L			1			
	2	0 L				1	0	
	3	0 L			1		3	
22	1	1 L			3		0	
	2	1 L					1	
	3	0 L			1		1	
	4	1 L			4	1	1	
	5	0 L					2	
	6	0 L			1		0	
	7	1 L			1		4	
	8	0 L			1		5	
	9	0 L					4	
	10	1 L					3	
	11	1 L			2		1	
	12	0 L			2	1	1	
	13	0 L					0	
	14	0 L					4	
	15	0 L					5	
	16	0 L					4	
	17	0 L					5	
	18	0 L			1		4	
	19	0 L					5	
	20	1 L					5	
	21	0 L					4	
	22	2 L			1		4	
	23	0 L					5	
	24	0 L					5	
	25	1 L			1		5	
	26	2 L					4	2*
	27	0 L					1	
	28	0 L					3	
23	1	1 L			1		0	
	2	1 L				2	0	

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	3	0 L						
	4	0 L						
	5	1 L						
	6	1 L						
	7	1 L			1			
	8	1 L			1			
	9	0 L						
	10	2 L						
	11	0 L						
	12	1 L						
	13	0 L						
	14	1 L						
	15	0 L						
	16	0 L				1		
	17	0 L						
	18	0 L						
24	1	0 L						
	2	1 L						
	3	0 L						
	4	0 L						
	5	0 L					3	
	6	0 L					4	
	7	0 L					5	
	8	0 L					4	
	9	1 L					5	
	10	0 L					4	
	11	0 L						
	12	0 L						
	13	0 L						
	14	0 L				1		
	15	0 L						
	16	0 L						
	17	0 L						
	18	0 L						
	19	0 L						
	20	0 L						
	21	1 L						
	22	0 L						
	23	0 L						
	24	0 L						
	25	0 L						
	26	1 L		1				
	27	0 L						
	28	1 L						
	29	1 L						
	30	0 L						
	31	0 L						
	32	0 L						
	33	1 L						
	34	3 L		1	1	1		
	35	1 L						
	36	0 L						
	37	2 L		1	1	1		
25	1	2 L						
	2	0 L						
	3	0 L						
	4	0 L						
	5	0 L						
	6	1 L			1			
	7	0 L						
	8	1 L			1			
	9	1 L						
	10	4 L			1	1		
	11	1 L						
	12	0 L						
	13	1 L						
	14	1 L				1		
	15	1 L						
	16	1 L						
	17	1 L						
	18	1 L						
	19	1 L						
	20	0 M						
	21	1 M						
	22	1 M						
	23	1 M						
	24	0 M						
	25	0 M						
	26	3 M		2	2			
	27	1 M						
	28	2 M						
	29	1 M						
	30	1 M			1	1		
	31	2 M						
	32	0 M			1			
	33	1 M			1	1		
	34	1 M						
	35	2 M						
	36	1 M						
	37	2 M			1	1		
	38	3 M			1			
	39	2 M						
	40	0 M			1	1		

TRANS	PLOT	CAAU BORROWS	Spacing m	CAAU 2nd E	CAAU ST-15	CAAU ST-15	RHAU	TUPU
	31	4	M				9	
26	1	X						
	2	X						
	3	X						
27	1	2	M					
	2	0	M					
	3	9	M					
	4	1						
	5	0						
	6	0						
	7	0						
	8	1			1	1	1	
	9	1			1		4	
	10	1			1		5	
	11	0					2	
	12	0					4	
	13	0					5	
	14	0					7	
	15	3			2	1	3	
	16	0					2	
	17	0					4	
28	1	0						
	2	1						
	3	0						
	4	1						
	5	1						
	6	0						
	7	2	M			1	3	
	8	3	M				3	
	9	4	M				0	
	10	3	M				0	
	11	3	M				0	
	12	0				1	0	
	13	1			1		1	
	14	2					2	
	15	0					3	
	16	2	M			1	2	
	17	6	M			1	1	
	18	0	M				4	
	19	1	M		1		4	
	20	2	M				9	
	21	1	M		1		2	
	22	3	M		2		2	
	23	2	M				2	
	24	2	M		1	1	5	
	25	0	M				4	
	26	4	M			1	2	
	27	6	M		2	2	0	
	28	4	M				5	
	29	3	M				2	
	30	2	M		3	1	4	
	31	3	M				2	
	32	4	M				4	
	33	5	M				3	
	34	4	M		1		5	
	35	8	M		1		2	
	36	6	M				2	
	37	2	M			1	5	
	38	4	M			1	9	
	39	5	M			1	3	
	40	5	M				1	
	41	4	M			1	0	
29	1	1	M				0	
	2	2	M	1			0	
	3	3	M	1			3	
	4	2	M				1	
	5	4	M		1		2	
	6	3	M			1	2	
	7	0					3	
	8	1					3	
	9	0					5	
	10	1					0	
	11	0					2	
30	1	0						
	2	0					0	
	3	1			1		0	
	4	0					0	
	5	0					0	
31	1	2						
	2	0						
	3	0						
	4	1						
	5	0						
32	1	0						
	2	0						
33	1	0						
	2	0						
	3	0						
	4	1						
	5	0						
	6	0						
34	1	3	M				3	
	2	2	M				1	

TRANS	PLOT	CAAU BORROWS	Spacing m	CAAU 2nd E	CAAU ST-15	CAAU ST-15	RHAU	TUPU
	3	3	M					
	4	2	M		1		1	
	5	3	M				1	
	6	0					1	
	7	0					1	
	8	4				1	1	
	9	0					1	
	10	0					1	
	11	0					1	
35	1	X						
	2	X						
	3	X						
	4	X						
36	1	3	M					
	2	1	M					
	3	2	M				1	
	4	5	M				0	
37	1	0						
	2	0						
	3	0						
	4	1				2		
38	1	1						
	2	0						
	3	3	M			1		
	4	6	M					
	5	4	M					
	6	4	M		1	1		
	7	6	M		1			
	8	4	M			1		
39	1	4	M		1			
	2	0						
40	1	1						
	2	0						
	3	0						
	4	0						
41	1	2						
	2	3	M					
	3	0						
	4	0						
42	1	X						
	2	X						
	3	7	M					
	4	3	M					
	5	3	M					
	6	3	M		1			
	7	3	M					
	8	6	M					
43	1	1	M					
	2	1	M					
	3	3	M					
	4	3	M		1	1		
	5	3	M					
	6	4	M			1		
	7	3	M					
	8	5	M					
	9	6	M			1		
	10	6	M					
	11	6	M					
	12	10	M		2			1
	13	3	M			1		1
44	1	0						
	2	0						
	3	5	M					
	4	5	M					
	5	3	M					
	6	1	M					
	7	1	M					
	8	1	M					
	9	5	M			1		
	10	6	M		1			
	11	5	M					
	12	6	M			1		
	13	6	M			1		
	14	6	M			1		

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST-15	CAAU ST-15	RHAU	TUPU
	10	5 M				1		
	11	0 M						
	12	9 H			1	1		
	13	7 H				1		
	14	9 H		1				
	15	9 H						
	16	9 H			1	1		
	17	13 H				1		
	18	8 H						
	19	13 H						
	20	11 H						
	21	13 H		1		1		
	22	10 H			1			
	23	16 H			1			
	24	12 H			1	1		
	25	11 H						
	26	15 H						
	27	11 H		2				
	28	7 H				2		
	29	11 H						
	30	13 H		1		1		
	31	9 H				1		
	32	13 H						
	33	5 M						
	34	5 M		1				
	35	0 M			1			
	36	2 M			1			
	37	3 M				1		
	38	5 M				1		
	39	20 H				1		
	40	15 H				2		
	41	9 H						
	42	0 L			1			
46	1	1 M						
	2	5 M						
	3	1 M						
	4	8 M						
	5	6 M		1	1			
	6	X						
	7	X						
	8	X						
	9	X						
	10	X						
	11	X						
	12	10 H						
	13	13 H			1			
	14	9 H			3	4		
	15	9 H						
	16	16 H			3			
	17	12 H			1			
	18	15 H				2		
	19	9 H			1			
	20	13 H			2	1		
	21	9 H			1	1		
	22	9 H						
	23	9 H			1			
	24	12 H						
	25	11 H			1			
	26	15 H						
	27	16 H			2			
	28	12 H			2			
	29	15 H						
	30	12 H				1		
	31	15 H						
	32	14 H			1			
	33	16 H			1	1		
	34	11 H			2	1		
	35	6 M			2	1		
	36	1 M						
	37	3 M			1	1		
	38	10 M		2	4	2		
	39	13 H		1	2	1		1*
	40	14 H		2	2	2		
	41	9 H			2	1		
	42	11 H		1	1	2		
	43	10 H		1		1		
	44	15 H			1	2		
	45	10 H			1			
	46	9 H			1	1		
	47	1 H			3			
	48	11 H			2	2		
	49	11 H						
	50	11 H						
	51	12 H			1	2		
	52	7 H			3			
	53	6 H			2			
47	1	0 L						
	2	0 L						
	3	5 M						
	4	0 M						
	5	2 M						
	6	6 M						
	7	3 M			1			

TRANS	PLOT	CAAU BURROWS	Spacing m	CAAU 2nd E	CAAU ST-15	CAAU ST-15	RHAU	TUPU
	8	3 L						
	9	0 L				1		
	10	0 L						
	11	0 L				1		
	12	3 L			2			
	13	11 M		1	1	1		
	14	11 M			2	1		
	15	11 M		1				
	16	7 M			2			
	17	6 M		2	2	1		
	18	12 M		2	3	1		
	19	10 M				2		
	20	15 M		2	1			
	21	3 M		1		1		
	22	9 M		2	2	2		
	23	4 M		1	2	1		
	24	9 M			4			
	25	9 M		3	2			
	26	8 M		1	3	2		
	27	9 M		1	3			
	28	5 M			3	1		
	29	3 M			2	3		
	30	1 M		1	3	1		
	31	5 M			1			
	32	3 M			5	3		
	33	6 M			6			
	34	11 M		1	1			
	35	11 M		1	1	1		
	36	11 M						
	37	9 M			4			
	38	11 M			5	2		
	39	9 M		1				
	40	4 M		1	1			
	41	11 M		1	1			
	42	11 M		1				
	43	9 M			4			
	44	7 M			4	1		
	45	7 M						
	46	9 M			1			
	47	6 M		1	4	2		
	48	4 M						
48	1	0 L						
	2	0 L						
	3	0 L						
	4	1 L				1		
	5	0 L						
49	1	1 L						
	2	0 L						
	3	3 L						
	4	3 L						
	5	0 L						
	6	0 L						
	7	0 L				1		
	8	1 L						
	9	1 L						
	10	0 L						
	11	0 L						
	12	0 L			1			
	13	0 L						
	14	1 L				1		
	15	1 L			1			
	16	6 M			2			
	17	4 M			3			
	18	5 M			1	1		
	19	4 M			2			
	20	17 M						
	21	11 M				2		
	22	14 M				1		
	23	11 M			3	2		
	24	6 M			1	1		
	25	9 M						
	26	7 M						
	27	9 M			1	1		
	28	9 M						
	29	11 M		1	2			
	30	1 M			2	1		
	31	8 M			1	1		
	32	13 M			1	1		
	33	11 M			1			
	34	9 M						
	35	9 M			1	2		
	36	2 M				1		
	37	0 M						
50	1	X						
	2	X						
51	1	1 L		1				
	2	0 L						
	3	0 L						
	4	3 M				3		
	5	8 M				1		
	6	1 M			1			
	7	2 M						
	8	4 M				1		

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
52	1	0	L			1		
	2	1	L		2			
	3	7	M	1	1	1		
	4	1	M			2		
	5	4	M					
	6	4	M			1		
	7	7	M					
	8	1	M			1		
53	1	4	M	1	1	1		2
	2	11	M			1		0
	3	10	M		2			1
	4	11	M					0
	5	6	M	1	1			2
	6	4	M					0
54	1	4	M					
	2	7	M					
	3	5	M			1		
	4	4	M					
	5	1	M			1		
	6	1	M					
	7	6	M		3			
	8	4	M					
	9	2	M		1	1		
	10	8	M			1		
	11	3	M			1		
	12	4	M		2			
	13	6	M	1				
	14	8	M	1	1			
	15	4	M					
	16	8	M		2			
	17	4	M		4	1		
	18	7	M			1		
	19	1	M		2			
55	1	0	L					
	2	2	L					
	3	0	L					
	4	0	L		1			
	5	3	M			1		
	6	3	M		3			
	7	2	M		1	3		
	8	8	M		1	1		
	9	6	M			2		
	10	5	M		2			
	11	5	M					
56	1	0	L					
	2	5	M					
	3	6	M		1			
	4	2	M		1	1		
	5	4	M					
	6	7	M		2			
	7	9	M		1	1		
	8	5	M					
	9	4	M		2	2		
	10	7	M		1	2		
	11	0	M		2			
	12	3	M		1			
	13	3	M		1			
	14	1	M		3	1		
	15	4	M		5			
	16	1	M		2			
	17	3	M		2			
	18	0	M		2			
	19	1	M		2			
	20	7	M		1			
57	1	0	L					
	2	2	M					
	3	6	M					
	4	6	M	1				
	5	4	M		1	1		
	6	3	M		3			
	7	0	M					
	8	6	M		2			
	9	6	M	1	1			
	10	9	H		2			
	11	9	H		2	2		
	12	5	H		1			
	13	10	H	1	1			
	14	3	H		3			
	15	10	H	1	1	2		
	16	6	H		2			
	17	12	H		1			
	18	0	M		1			
	19	5	M		1			
58	1	2	M					
	2	7	M					
	3	7	M					
	4	9	H			2		
	5	7	H		2			
	6	9	H		1			
	7	7	H					
	8	8	H		3			
	9	8	H	2	2	1		
	10	9	H		1			

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	11	8	H		4			
	12	9	H			3		
	13	7	H					
	14	11	H			3	1	
	15	4	H	1		3		
	16	9	H	1		1	1	
	17	6	H					
	18	4	H			1	3	
	19	9	H			1	1	
	20	10	H	1		1		
	21	5	H	1		3	2	
59	1	X						
	2	6	M					
	3	11	H			1		
	4	9	H			1		
	5	10	H			1		
	6	12	H				2	
	7	7	M	1				
	8	7	M			1	1	
	9	5	M				1	
	10	9	M			2		
	11	6	M			2		
	12	3	M			2	1	
	13	1	M			1		
	14	9	H			1	2	
	15	9	M	1		1		
60	1	7	L				1	
	2	1	L					
61	1	2	M					
62	1	4	M			2	2	
	2	7	M					
	3	4	M				1	
	4	4	M			1	1	
	5	6	M					
	6	9	M	1				
	7	4	M			1		
	8	9	M			1		
	9	6	M			2		
	10	2	M					
	11	1	M					
	12	1	M					
	13	5	M					
63	1	0	L					
	2	2	L					
	3	0	L					
	4	0	L					
	5	1	L					
	6	0	L			1	1	
	7	3	L			1		
	8	2	L					
	9	0	L			2		
	10	0	L			1		
	11	0	L					
	12	2	L				1	
	13	0	L			1		
	14	0	L			1		
	15	3	L					
	16	1	L					2
64	1	0	L					
	2	1	L			1		
	3	1	L					
	4	0	L					
	5	1	L			1		
	6	0	L					
65	1	0	L			1		
	2	1	L			1		
	3	X						
	4	X						
	5	X						
	6	X						
66	1	0	L					
	2	3	M			1		
	3	3	M					
	4	1	L			3	1	
	5	0	L					
	6	0	L			1		
Side transects begun higher on slopes								
67	1	2	M					4
	2	2	M					2
	3	1	M			1		3
	4	0	M					1
	5	2	M			4		2
	6	6	M			2		2
	7	3	M			3		0
	8	0	M					0
	9	0	M			1		0
	10	2	M			3		0
	11	3	M				1	0
	12	5	M	2				0
	13	8	M					1
	14	8	M					0
	15	10	M					0
	16	11	M	1				0

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	17	9 H		1		1		0
	18	7 H				1		0
	19	16 H		1				0
	20	12 H			1			1
	21	14 H		2				0
	22	16 H		2				0
	23	16 H		1		1		0
	24	16 H		3				0
68	1	2 M				1		
	2	3 M			2	2		
	3	3 M						
	4	0 M						
	5	0 M						
	6	4 M			2			
	7	4 M						
	8	2 M			2			
	9	5 M			1	1		
	10	6 M			2			
	11	1 M			1			
	12	3 M			1	1		
	13	5 M			4			
	14	5 M			1			
	15	2 M		1				
	16	1 M			2			
	17	5 M			2			
	18	0 M			3			
	19	6 M		1	2			
	20	4 M			3			
	21	7 M			2			
	22	5 M		1	1	1		
	23	5 M			1			
	24	5 M			2			
	25	1 M			1			
	26	0 M						
	27	1 M						
	28	5 M		1	1			
	29	4 M			2			
	30	5 M						
	31	2 M			1			0
	32	5 M			3			1
69	1	6 M			1			2
	2	12 M						0
	3	2 M			1			
	4	0 M			2	2		
	5	2 M			4			
	6	2 M		1				
	7	3 M			1			
	8	0 M				1		
	9	2 M			1	1		
	10	2 M			1			
	11	7 M				1		
	12	8 M		1	1			
	13	7 M			2			1
	14	9 M			1			
	15	7 M		1	2	2		
	16	4 M			1			
	17	7 M			1			
	18	3 M						
	19	5 M						
	20	6 M		1	3			
	21	9 M			2	1		
	22	4 M			1			
70	1	X			2			
	2	2 M			1			
	3	1 M			3			
	4	7 M			1			
	5	5 M				1		
	6	4 M						
	7	0 M						
	8	4 M			5	2		
	9	1 M			1			
	10	6 M						
	11	2 M			1			
	12	1 L						
	13	0 L			3			
	14	0 L						
	15	2 L			1			
	16	0 L						
	17	1 L			2			
	18	3 L			1	1		
	19	1 L						
	20	0 L						
	21	2 L			1			
	22	1 L			1			
	23	5 M						1
	24	6 M						
	25	4 M			1	1		
	26	4 M						
	27	5 M		1	2	1		
	28	3 M			1	1		
71	1	2 M						4
	2	4 M			2			2
	3	8 M			2			1

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	4	12 M			1			
	5	4 M			1			
	6	5 M						
	7	7 M						
	8	6 M		1	1			
	9	4 M			1			
	10	6 M					1	
	11	2 M			1			
	12	0 M			2	1		
	13	3 M						
	14	2 M						
	15	3 M			1			
	16	0 L			1	1		
	17	3 L			4			
	18	1 L				1		
	19	4 L			2			
	20	1 L			2			
	21	0 L						
72	1	5 M			1			3
	2	8 M						1
	3	6 M				1		2
	4	3 M						2
	5	11 H		1	1			1
	6	12 H			1			0
	7	15 H			2			2
	8	11 H						1
	9	0 M						
	10	0 M						
	11	9 M					1	
	12	7 M			4		0	
	13	6 M			1		1	
	14	9 M				1	1	
73	29	1 L					2	
	30	3 L			1		3	
	31	1 L			2		5	
	32	2 L			1		3	
	33	1 L			1		1	
	34	3 L		1	1		2	
	35	0 L				1	0	
	36	1 L					1	
	37	0 L					0	
74	27	5 M			2		2	
	28	3 M			4		4	
	29	6 M			2		1	
75	1	1 L			1	1		2
	2	1 L			2	1		2
	3	5 M			1			1
	4	4 M			1			2
	5	6 M						2
	6	1 L			1			
	7	1 L						
76	1	5 M			1			2
	2	4 M				1		3
	3	3 M			3			0
	4	4 M			5			1
	5	4 M			2			2
	6	0 L						0
77	1	4 M		1	2	1		
	2	5 M				2		
	3	15 H			1			
	4	14 H						
	5	12 H		1	2	1		
	6	10 H						
	7	10 H			1			
	8	15 H				1		
	9	11 H		1	2			
	10	6 H			1			
	11	6 H			1			
	12	9 H				2		
	13	16 H				2		
	14	13 H						
	15	5 M				1		
	16	2 M						
Top of main island								
T-1	1	9 H						
	2	13 H		1		1		
	3	9 H						
	4	4 M			1	1		
	5	0 M						
	6	6 M				1		
	7	17 H						
T-2	1	3 M					3	
	2	9 H				1	2	
	3	9 H					1	
	4	11 H			1	1	0	
	5	11 H					4	
	6	15 H				1	2	
	7	18 H		3	2		1	
	8	9 H				1	3	
	9	16 H					0	
	10	12 H			4	1	3	
	11	11 H			3		4	1
T-3	1	X						

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	2	0	L					2	
	3	1	L				1	4	
	4	0	L						
	5	0	L						
	6	0	L			2			
	7	2	M				2	5	
	8	2	M			2	1	2	
	9	2	M			1		3	
	10	4	M			1	1	0	
	11	0	M					0	
	12	3	M			1		2	
	13	5	M				1	2	
	14	2	M					3	
	15	4	M		1		2	3	
	16	1	L			1	1	3	
	17	0	L						
	18	1	L						
	19	2	L						
	20	0	L						
	21	2	M						
	22	2	M			1			
	23	2	M			2			
	24	1	M			1		6	
	25	4	M			1		3	
	26	1	L				1	3	
	27	0	L			1	1	0	
T-4	1	0	L			1			
	2	2	T	50		2			
	3	4	M				1	2	
	4	2	M					2	
	5	2	M			2		1	
	6	5	M			2		0	
	7	0	M						
	8	4	M			1		3	
	9	1	M			2	2	2	
	10	2	M		2	3	3	2	
	11	6	M					4	
	12	2	M			2	1	4	
	13	0	L					0	
	14	1	L		2			2	
T-5	1	X							
	2	0	L					7	
	3	1	L			1	2	6	
	4	1	L					3	
	5	0	L					3	
	6	3	L			1		2	
	7	2	L			1	1	5	
	8	1	L					5	
	9	0	L					1	
	10	0	L					0	
	11	1	L			1		4	
	12	2	L		1			0	
	13	1	L			1		2	
	14	3	L			3		2	
	15	1	L		1	1	1	5	
	16	1	L				1	3	
	17	0	L					1	
	18	1	L				1	2	
	19	0	L					0	
T-6	1	0	L					2	
	2	1	L				1	4	
	3	3	L					4	
	4	3	L			1		4	
	5	2	L			2		2	
	6	1	L					1	
	7	0	L					1	
	8	0	L					1	
	9	0	L			2		0	
	10	0	L					0	
	11	0	L			1	2	0	
	12	0	L			1		4	
	13	1	L			1		6	
	14	1	L			3		3	
	15	1	L				1	2	
T-7	1	X	L						
	2	5	M					6	
	3	1	M						
	4	3	M						
	5	5	M			1			
	6	1	L			3			
	7	0	L						
	8	0	L						
	9	5	M		1			2	
	10	0	M			1		0	
	11	4	M		1	1		0	
	12	5	M				1	5	
	13	10	M					1	
	14	10	M			1		2	
	15	6	M			2		2	
	16	7	M					2	
	17	2	M			1	1	4	
	18	2	M					4	
	19	0	L					1	

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
T-8	1	0	L					3	
	2	2	L		1	3		1	
	3	1	L					0	
	4	1	L					0	
	5	5	M					2	
	6	7	M		1			2	
	7	3	M		1			2	
	8	5	M			1			
	9	3	M		1		1		
	10	3	M			1			
	11	3	M		1				
	12	6	M						
	13	0	L						
	14	0	L						
	15	0	L						
	16	0	L						
	17	0	L						
	18	2	M						
	19	12	M					1	
	20	2	M			2	1	2	
T-9	1	5	M				1	4	
	2	8	M		2			3	
	3	6	M				1		
	4	3	M						
	5	7	M						
	6	5	M						
	7	3	M					1	
	8	3	M			2		0	
	9	1	T	5				1	
	10	1	T	25			1	1	
	11	0	T	5				4	
T-10	1	5	M					2	
	2	2	M			1	1	2	
	3	1	M						
	4	1	M						
	5	2	M						
	6	2	M						
	7	1	M						
T-11	1	3	M			1	1	1	
	2	1	M					0	
T-12	1	6	M			1	1		0
	2	3	M						
T-13	1	0	T	20		1			
	2	3	T	20					
	3	0	T	20					
	4	1	T	20					
	5	0	T	20					
	6	0	T	20					
T-14N	1	3	M			1			
	2	9	M						
	3	5	M						
	4	4	M						
	5	2	M						
	6	6	M				2		
	7	6	M						
	8	2	M				1		
	9	1	M						
	10	5	M		1				
	11	1	T	5		1			
	12	0	T	5					
T-14S	13	2	T	5				2	
	14	1	T	5			1	1	
T-15	1	5	M					2	
	2	9	M			1			
	3	8	M			1			
	4	0	T	5		1			
	5	0	T	5					
	6	0	T	20					
	7	3	M						
	8	6	M						
	9	2	M						
	10	1	T	5					
	11	2	T	5					
	12	0	T	5					
	13	0	T	15					
	14	0	T	20					
T-16N	1	1	T	5					
	2	0	T	5					
T-16S	1	5	M					3	
	2	9	M		1			1	
	3	2	M						
T-17	1	5	M					3	
	2	6	M						
	3	8	M						
	4	1	T	10					
	5	0	T	20					
	6	0	T	20					
	7	0	T	20					
	8	0	T	20					
	9	0	T	20					
	10	7	M						
	11	9	H		1	1		2	
	12	12	H				1	3	

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
T-19N	1	10 M			2		2	
	2	5 M			3	2	2	
	3	5 M			2		3	
	4	2 M			1			
	5	3 M			1			
	6	7 M			2		2	
	7	7 M				1	0	
	8	8 M			1	1	1	
	9	2 M						
	10	2 M			1		2	
	11	3 M						
	12	3 M				1		
	13	0 T	5					
	14	1 T	5					
T-18S	1	11 H		1				
	2	12 H						
	3	3 M						
	4	4 M						
	5	3 M						
	6	9 M						
	7	1 T	5		3			
T-19	1	3 M						
	2	0 T	5		2	1		
	3	0 T	15					
	4	0 T	20					
	5	0 T	20					
	6	0 T	20					
	7	0 T	20		1			
	8	1 T	20			1		
	9	3 M					0	
T 20N	1	10 M						
	2	0 M				1		
	3	3 M						
	4	4 M				1		
	5	0 T	5		2			
T-20S	1	7 H					0	
	2	3 M				1	0	
	3	1 T	5		1	1		
T-21	1	1 M			1			
	2	4 M			1	1		
	3	6 M				1		
	4	2 M			1			
	5	4 M						
	6	2 M						
	7	3 M						
	8	0 T	5					
	9	0 T	5					
	10	1 T	20	1				
	11	1 T	10		1			
	12	4 M		1	2	1		
	13	4 M					0	
	14	10 H			1		2	
T-22N	1	0 T	5					
T-22S	1	10 H				1		
	2	7 H			1			
	3	11 H			1	1		
	4	9 H			2			
	5	11 H						
	6	7 M				1		
	7	2 M		1	1			
	8	0 T	5					
T-23	1	11 H		1	1		2	
	2	12 H			2		1	
	3	9 H		2	4		1	
	4	13 H			1		3	
	5	13 H					2	
	6	14 H			2			
	7	14 H						
	8	13 H			1	1		
	9	10 H			1			
	10	5 M						
	11	5 M						
	12	6 M		1	1			
	13	0 T	20					
	14	0 T	20					
	15	0 T	20					
	16	0 T	20					
	17	0 T	20					
	18	0 T	20					
T-24	1	3 M					1	
	2	14 H		1				
	3	9 H			1	2		
	4	11 H			2	1		
	5	5 M				2		
	6	3 M			3			
	7	0 T	5			1		
T-25	1	7 M		2	1			
	2	4 M						
	3	9 M			1	1		
	4	1 T	5					
	5	3 T	5					
	6	1 T	5					
T-26	1	2 M			5			

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	2	2 M						
	3	0 T	5					
	4	0 T	5		1			
	5	0 T	5					
T-27	1	4 M		1	1			
	2	0 T	5			1		
	3	0 T	5					
T-28	1	10 H		1	1			
	2	3 M				1		
	3	0 T	5					
T-29E	1	0 T	5					
	2	0 T	20					
	3	0 T	20					
	4	5 T	20			1		
T 29W	1	11 H				1		
	2	6 M				1		
	3	4 M						
	4	3 M						
	5	9 M						
	6	5 M		1	1	1		
	7	10 M						
	8	8 M		1	1			
	9	8 M			1			
	10	5 M				1		
	11	1 M						
	12	3 M				1		
	13	2 M				1		
	14	8 M				1		
	15	2 M						
	16	0 T	5					
	17	1 T	5					
	18	0 T	20					
	19	1 T	20					
	20	0 T	20					
	21	2 T	20					
	22	1 T	20					
	23	1 T	5					
	24	2 M				1		
	25	3 M						
	26	2 M						
	27	2 M						
	28	2 M						
	29	2 M						
	30	1 T	5					
	31	2 T	20					
T-30	1	10 H		2	2			
	2	8 H		1		1		
	3	3 M						
	4	2 M						
	5	0 M						
	6	12 M		1				
	7	5 M						
	8	6 M			1			
	9	5 M						
	10	1 M			1	1		
	11	5 M			2			
	12	5 M			3			
	13	4 M						
	14	0 T	5					
	15	0 T	5			1		
	16	0 T	10					
	17	0 T	20					
	18	5 M			1	1		
	19	7 M						
	20	3 M						
	21	1 T	5					
T-31E	1	0 T	5			1		
	2	0 T	20					
	3	1 T	20					
	4	0 T	20					
T-31W	1	0 T	20					
	2	1 T	20			1		
	3	0 T	20					
	4	1 T	20					
	5	0 T	20					
	6	1 T	20					
	7	1 T	20		2			
	8	0 T	20					
	9	4 M				1		
	10	6 M						
	11	4 M				1		
	12	5 M						
	13	7 M				1		
	14	7 M			1			
	15	6 M						
	16	0 M						
	17	6 M						
	18	0 T	5			1		
	19	0 T	5					
	20	3 M			2	1		
	21	7 M		2	1			
	22	6 M		2				
	23	0 M						

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	24	1	M				1		
	25	3	M						
	26	6	M			1			
	27	8	M						
	28	9	M						
	29	6	M				2		
	30	5	M						
	31	3	M			2			
	32	0	M				1		
	33	1	M						
	34	5	M		1	1	1		
	35	1	M						
	36	2	M						
	37	2	M				1		
	38	9	M						
	39	7	M						
	40	4	M				1		
	41	4	M						
	42	6	M				2		
	43	8	H				3		
T-32C	1	1	T	5		1			
	2	2	M		1	4			
	3	4	M			3			
	4	0	M				1		
	5	4	M		1	1			
	6	2	M			3			
	7	1	T	5		1			
	9	0	T	5		2			
T-32W	1	8	H						
	2	10	H		2				
	3	13	H						
	4	8	H		1				
	5	2	M						
	6	2	M						
	7	0	M						
	8	2	M						
	9	6	M		1				
	10	2	M						
	11	6	M				2		
	12	3	M			1	1		
	13	3	M			1			
	14	3	M						
	15	3	M				1		
	16	3	M				1		
	17	4	M						
	18	4	M						
	19	5	M						
	20	4	M						
	21	6	M						
	22	2	M						
	23	0	T	5					
	24	0	T	5					
T-33E	1	2	M			2			
	2	3	M						
	3	7	M						
	4	5	M		1				
	5	3	M						
	6	3	M			1			
	7	5	M						
	8	2	M						
	9	4	M		2				
	10	2	M						
	11	0	T	5		1			
	12	0	T	5					
	13	0	T	20					
	14	9	M						
	15	3	M		1	2			
	16	2	M						
	17	0	T	5					
	18	0	T	10					
	19	1	T	20					
	20	6	M						
	21	0	T	5					
	22	0	T	20					
	23	0	T	20					
	24	0	T	20					
	25	0	T	20					
	26	2	M				1		
T-33W	1	0	T	5					
	2	2	T	5					
	3	1	T	5		2	3		
	4	1	T	5					
	5	0	T	5		2	6		
	6	4	T	5		1			
	7	0	T	15					
	8	0	T	20					
	9	0	T	20					
	10	0	T	20					
	11	3	T	20		1	1		
	12	0	T	20					
	13	2	T	20		3			
	14	4	M						
	15	3	M			1			

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	16	4	M		2	3			
	17	7	M		1				
	18	3	M						
	19	0	T	20					
	20	8	M			1			
	21	4	M		1				
	22	0	M						
	23	1	M						
	24	6	M		1				
	25	0	T	5					
	26	0	T	15					
	27	3	M			2			
	28	4	M						
	29	4	M			1			
	30	4	M						
	31	1	M				1		
	32	3	M		1				
	33	7	M				1		
	34	4	M			2	2		
	35	3	M						
	36	2	M			2	1		
	37	3	M						
	38	1	M			1			
	39	0	M						
	40	6	M			1	1		
	41	4	M		1				
	42	0	T	5					
	43	0	T	5					
	44	0	T	5					
	45	3	M						
	46	5	M			1			
	47	3	M						
	48	1	M						
	49	0	M						
	50	2	M						
	51	5	M						
	52	4	M						
	53	1	M						
	54	2	M						
	55	1	M						
	56	0	M						
	57	4	M						
	58	2	M			1			
	59	2	M			1			
	60	2	M						
	61	4	M						
	62	3	M						
	63	9	M						
	64	3	M			1			
T-34E	1	2	T	5		2			2
	2	1	T	5					4
	3	1	T	5			1		2
	4	0	T	5		1			3
	5	0	T	5					
T-34C	1	4	M			1			
	2	5	M						
	3	11	M		1	1			
	4	7	M						
	5	3	M			1			
	6	3	M						
	7	3	M						
	8	5	M						
	9	7	M			1			
	10	7	M		1				
	11	3	M						
	12	1	M						
	13	3	M						
	14	1	M						
	15	4	M						
	16	2	M						
	17	5	M				1		
	18	4	M						
	19	8	M		1				
	20	7	M			1			
	21	6	M						
	22	7	M						
	23	9	M		2				
	24	6	M						
	25	8	M			2	1		
	26	4	M			1			
	27	2	M						
	28	1	M						
	29	2	M						
	30	2	M						
	31	0	T			1			
T-34W	1	5	M			3			
	2	1	M						
	3	3	M						
	4	7	M						
	5	1	T	5					
	6	0	T	5					
T-35E	1	4	M			1			
	2	2	M		1	2	1		

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	3	9 M		2				
	4	4 M		1	2	1		
	5	5 M						
	6	1 M						
	7	4 M		1	1			
	8	4 M		2				
	9	1 T	5			1		
	10	1 T	20					
	11	2 M						
	12	3 M		1				
	13	6 M						
	14	6 M						
	15	7 M						
	16	6 M			1			
	17	2 M			1			
	18	5 M		2				
	19	4 T	10					
	20	1 T	20					
	21	8 M			1			
	22	6 M			1			
	23	2 M						
	24	1 T	5			1		
	25	1 T	5		1			
	26	0 T	5		2			
	27	0 T	5		1			
	28	2 T	20				5	
T-35W	1	5 M		2	2			
	2	2 M						
	3	3 M		2				
	4	5 M			1			
	5	0 M				2		
	6	0 M						
	7	6 M		1	1			
	8	3 M						
	9	8 M		1	1			
	10	6 M			1			
	11	4 M						
	12	5 M		2				
	13	6 M			3			
	14	6 M						
	15	6 M		1	3			
	16	5 M			1			
	17	5 M						
	18	5 M						
	19	8 M			1			
	20	1 T	5		1	1		
	21	0 T	5					
	22	2 T	5		1			
	23	1 T	5					
	24	0 T	5					
	25	2 M						
	26	3 M		1		1		
	27	7 M		2		1		
	28	4 M				1		
	29	2 M						
	30	3 M						
	31	1 M						
	32	6 M				1		
	33	3 M						
	34	6 M			1	1		
	35	0 M						
	36	9 M						
	37	0 T	5					
	38	2 T	20					
	39	3 T	20					
	40	4 T	20	1	1			
	41	2 T	20					
	42	3 T	20					
	43	0 T	20					
	44	0 T	20					
	45	0 T	20					
	46	4 T	20			1		
	47	0 T	20					
	48	0 T	20					
	49	4 M			1			
	50	1 M						
	51	5 M			1	1		
	52	4 M						
	53	8 M			1			
	54	1 M						
	55	0 M						
	56	0 M						
	57	4 M		1	2			
	58	6 M				2		
T-36E	15	3 T	5		1		2	
	16	0 T	5				3	
	17	3 T	5				0	
	18	1 T	5				0	
	19	0 T	5		1		0	
	20	6 M					1	
	21	5 M			1	1	0	
	22	6 M		1			0	
	23	3 M					1	

TRANS	PLOT	CAAU BURROWS	Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	24	2 M			1		0	
	25	5 M					0	
	26	3 M			1		3	
	27	6 M						
	28	2 M			1			
	29	3 M				1		
	30	3 M		1				
	31	8 M			1			
	32	1 M						
	33	1 M						
	34	3 M		2				
	35	3 M						
	36	5 M						
	37	5 M			1			
	38	5 M		1	1			
	39	8 M		1				
	40	4 M		1	1			
	41	3 M				1		
	42	3 M		1				
	43	5 M		1				
	44	5 M		1				
	45	8 M			2			
	46	4 M		1	1			
	47	4 M		1	1			
	48	3 M		1				
	49	5 M		1				
	50	9 M		2	1			
	51	10 M			1	1		
	52	9 M		1		1		
	53	9 M		1				
	54	12 M		2	1			
	55	9 M						
	56	3 M						
	57	5 M			1			
	58	8 M			1			
	59	6 M						
	60	9 M		2				
	61	8 M		1		1		
	62	10 M						
	63	4 M				2		
	64	5 M			1			
	65	6 M		1	1	1		
	66	2 M			1			
	67	4 M			1	1		
	68	1 T	5					
T-36W	1	3 M						
	2	6 M		1				
	3	6 M						
	4	5 M		1		1		
	5	4 M						
	6	5 M			1			
	7	3 M			1			
	8	5 M						
	9	3 M						
	10	6 M						
	11	1 T	5					
T-37E	1	2 M			1			
	2	9 M				2		
	3	6 M		1				
	4	7 M			1			
	5	2 M		1				
	6	0 M						
	7	2 M						
	8	11 M		1	1			
	9	4 M						
	10	5 M		2				
	11	2 M		1				
	12	2 M						
	13	4 M		1	1			
	14	6 M						
	15	6 M						
	16	5 M		1	1			
	17	5 M		2				
	18	7 M		1				
	19	10 M		1	2			
	20	8 M						
	21	2 M						
	22	1 M			2			
	23	3 M			1			
	24	0 T	5					
	25	0 T	5		1			
T-37W	1	11 H		3				
	2	8 H		1				
	3	8 H		3	1			
	4	10 H			1			
	5	7 H		2	2			
	6	4 H		1	1			
	7	12 H		3	1			
	8	12 H		1	1	2		
	9	6 M						
	10	1 T	5			1		
	11	1 T	15					
	12	1 T	20		1			

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	13	0	T	20					
	14	0	T	20		1			
	15	1	T	20					
	16	0	T	20					
	17	1	T	20			2		
	18	3	T	20					
	19	0	T	20					
	20	0	T	20					
	21	0	T	20		1			
	22	0	T	20					
	23	0	T	20					
	24	0	T	20					
	25	0	T	20					
	26	0	T	20					
	27	8	M						
	28	9	M			2	1		
	29	6	M			1			
T-38E	1	2	M						
	2	6	M		1	1			
	3	9	M		1	1			
	4	6	M			1			
	5	8	M			2			
	6	8	M		1	1			
	7	10	M			1			
	8	9	M		1		1		
	9	7	M		1	1	1		
	10	3	M			2			
	11	3	M		1		1		
	12	3	M						
	13	1	M		1	1			
	14	2	M						
	15	5	M						
	16	7	M						
	17	9	M		3	2			
	18	5	M		1	1	1		
	19	1	M						
	20	6	M		2				
	21	2	M						
	22	2	M						
T-38W	1	6	M		2				
	2	5	M		3	1			
	3	8	M		2	1			
	4	8	M		2	1			
	5	5	M				1		
	6	2	T	5					
T-39	1	9	H		1				
	2	3	M			1			
	3	2	M		2	1	1		
	4	5	M						
	5	6	M						
	6	8	M		2	3			
	7	2	M						
	8	0	M						
	9	2	M						
	10	2	M						
	11	3	M						
	12	0	T	10					
	13	0	T	20					
	14	1	T	20					
	15	3	T	20		3	1		
	16	4	T	20		2	1		
	17	1	T	20					
	18	0	T	20					
	19	0	T	20					
	20	0	T	20					
	21	0	T	28		1			
	22	0	T	20					
	23	0	T	20		1			
	24	0	T	20					
	25	1	T	20					
	26	1	T	20			2		
	27	0	T	20					
	28	4	M						
T-40E	1	2	M			2			
	2	4	M			2			
	3	2	M						
	4	8	M		2	1			
	5	5	M						
	6	7	M		2				
	7	6	M		1	1			
	8	3	M		1				
	9	3	M						
	10	2	M			1			
	11	0	M						
	12	0	M						
	13	10	M		1	1			
	14	9	M			1			
	15	0	T	5					
	16	0	T	5					
	17	3	T	5	1				
	18	1	T	5					
	19	2	T	5					
	20	0	T	5		2			

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	21	2	T	5					
	22	1	T	5					
	23	1	T	5		2			
	24	3	T	5					
T-40W	1	5	M			1			
	2	7	M		2		1		
	3	10	M			1			
T-41	1	2	M			1			
	2	10	M		1				
	3	0	T	15					
	4	1	T	20					
	5	0	T	20					
	6	0	T	20		1			
	7	0	T	20					
	8	3	M						
	9	1	M						
	10	6	M			2			
	11	8	M						
	12	6	M		1	3			
	13	5	M		1	3			
	14	3	M			1			
	15	1	T	5					
	16	0	T	5					
	17	0	T	20					
	18	0	T	20					
	19	0	T	20		1			
	20	0	T	20					
	21	1	T	20		1			
	22	4	M		1	1			
	23	8	M						
	24	6	M		1	1			
	25	3	M			1	1		
	26	4	M		1	1			
	27	4	M			1			
	28	0	T	15					
	29	0	T	20					
	30	0	T	20					
	31	0	T	20					
	32	10	H		2				
T-42	1	10	H						2
	2	16	H		4	3			
	3	9	H		3	1			
	4	10	H		2	3			
	5	8	H		1	4			
	6	5	M			2			
	7	2	M						
	8	8	M			1			
	9	0	T	5					
T-43	1	8	H			1			
	2	12	H			1			
	3	12	H		2	2			
	4	3	M		1				
	5	0	M						
	6	4	M				1		
T-44	1	9	H		2				
	2	2	M			2			
	3	6	M		1		1		
	4	5	M			2			
	5	6	M			1			
	6	5	M						
	7	1	M						
	8	2	M				1		
	9	0	T	5		2			
T-45	1	14	H		2				
	2	1	M						
	3	0	M						
	4	6	M		1	3			
	5	9	M			1	1		
	6	1	T	5					
T-46	1	2	M			2			
	2	4	M			1			
	3	4	M				1		
	4	1	T	5		1			
T-47	1	1	M				1		
	2	2	M				1		
	3	0	T	5					
T-48	1	10	H			2	1		
	2	3	M			1			
	3	9	M			1	1		
	4	0	T	5					
T-49	1	3	M		1				
	2	2	M				1		
	3	1	M			1	1		
	4	8	H		1				
	5	11	H		4	1			
	6	6	M						
	7	2	M						
	8	0	T	5					
	9	2	T	5					
	10	0	T	5					
	11	0	T	5					
	12	5	M				1		
	13	6	M			1	2		

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	14	8	M						
	15	4	M		1		2		
	16	3	M				3		
	17	3	M			1			
	18	0	T	5					
T-50	1	9	H						
	2	2	M						
	3	2	M						
	4	0	M						
	5	3	M						
	6	5	M			1	1		
	7	5	M						
	8	4	M		1				
	9	1	M			3			
	10	5	M						
	11	5	M						
	12	0	T	5					
T-51	1	5	M			1			0
	2	8	H						
	3	10	H						
	4	1	M			1	1		
	5	5	M		2				
	6	6	M			1			
	7	11	M						
	8	1	T	5					
T-52	1	9	H						0
	2	10	H				1		
	3	10	H		1		2		
	4	14	H			1			
	5	11	H						
	6	12	H						
	7	7	M				1		
	8	1	M			1			
	9	2	M			2			
	10	7	M		1				0
	11	4	M						
	12	1	T	5			1		
T-53	1	4	M						2
	2	7	M						2
	3	11	H						
	4	13	H			1			
	5	17	H						
Puffin Rock									
P-1	1	4	M		1	1			2
	2	1	M						3
	3	6	M		1				2
	4	0	M						0
	5	3	M			1			2
	6	2	M			1			7
	7	4	M						3
P-2	1	0	L						
	2	0	L			1			
P-3E	1	3	M			1			2
	2	0	M			2			4
	3	2	M						5
	4	7	M						1
	5	2	M				1		0
	6	2	M						2
	7	4	M						2
	8	5	M			2			4
P-3W	1	1	L			1			1
	2	2	L						1
	3	0	L			1			0
	4	1	L						4
	5	6	M			2			
	6	10	H			2			
	7	9	H			1			
	8	13	H			1			
	9	9	H						1
	10	9	H						1

TRANS	PLOT	CAAU BURROWS		Spacing (m)	CAAU 2nd E	CAAU ST>15	CAAU ST<15	RHAU	TUPU
	11	6	M			2			3
	12	5	M			1	1		3
P-4	1	2	M			2	1		0
	2	5	M						3
	3	7	M			1			1
	4	1	M			1	1		3
	5	2	M			2	1		1
	6	4	M			1			1
	7	8	M			2	1		
	8	14	H						
	9	10	H						
	10	11	H						
	11	12	H						
	12	16	H						
	13	10	H				2		
	14	11	H				1		
	15	9	H						
	16	7	H		1				
	17	9	M						
	18	7	M						
	19	7	M						
	20	6	M			1			
	21	1	M				1		
	22	4	M						
	23	0	M			1			
	24	0	M						
	25	5	M						
	26	6	M			1			
	27	7	M				1		
	28	9	M				1		
	29	3	M			1	1		5
P-5	1	3	M				1		2
	2	5	M						2
	3	6	M						0
	4	6	M		1				0
	5	11	M			1			1
	6	8	M			1			0
	7	1	M				1		1
	8	0	M			1			
	9	2	M						
	10	4	M						
	11	6	M		1	2			
	12	1	M						
	13	0	M						
	14	0	M						
	15	3	M		1				
	16	2	M						
	17	3	M						
	18	1	M						
	19	2	M						
	20	6	M						
	21	5	M						
	22	1	M			1			
	23	1	M						
	24	1	M						
	25	1	M						
	26	3	M		1	2			1
P-6	1	3	M			1			0
	2	5	M						1
	3	2	M						2
P-7	1	7	M						
	2	10	M						
	3	5	M			1			
	4	6	M				2		1
	5	4	M			3			0
P-8	1	1	M						1
	2	2	M						1
	3	3	M				2		1
	4	4	M						
	5	2	M						

habitat are underestimated by the percentages presented in Table SC010-18. Burrows that occurred under tall salmonberry, but whose entrances were not associated with salmonberry roots, were coded as in open ground. Thus the percentage listed of burrows in open ground include a portion (not calculated) under salmonberry canopy. Logs referred to in Table SC010-18 are old telegraph poles buried in the shrubbery near the lighthouse foundations. Mean length of a sample of 239 burrows was 0.8 ± 0.3 m (S.D.; range = 0.3 to 2.0 m).

Table SC010-18. Habitat locations of Cassin's Auklet burows along transects on Triangle Island in 1989.

Burrow locations	Number	Percent
Grass tussock	3301	41.2
Shrubbery	1618	20.2
Open ground	1425	17.8
Fern	724	9.0
Forb	409	5.1
Into bank	326	4.1
Rock	117	1.5
Driftwood	57	0.7
Dead crabapple roots	3	0.0
Log	2	0.0
Live crabapple roots	1	0.0

1989 Population estimate:

Number of sample plots:

At 5 m intervals:	Higher density:	322 (1.2% of colony)
	Medium density:	1067 (1.2% of colony)
	Lower density:	481 (1.0% of colony)
	Overall sampled at 5 m intervals:	1870 (1.1% of colony)
	Top-low sampled at > 5 m intervals:	248 (0.4% of colony)
	Overall:	2118 (0.9% of colony)

Average density:

	Higher density:	25,807 ± 425 burrows/ha
	Medium density:	9,992 ± 186 burrows/ha
	Lower density:	1,450 ± 98 burrows/ha
	Overall sampled at 5 m intervals:	10,518 ± 224 burrows/ha
	Top-low sampled at > 5 m intervals:	1,561 ± 198 burrows/ha

Colony area:

	Higher density:	10.7 ha
	Medium density:	36.2 ha
	Lower density:	18.4 ha
	Overall sampled at 5 m intervals:	65.3 ha
	Top-low sampled at > 5 m intervals:	28.0 ha
	Overall:	93.3 ha

Total burrows:

	Overall sampled at 5 m intervals:	686,482 ± 14,620
	Top-low sampled at > 5 m intervals:	43,701 ± 5,543
	Total:	730,183 ± 15,635

1989 Occupancy rate: 75.0 ± 3.1% (195 of 260)

1989 Nesting population: 547,637 ± 25,748 pairs

Hatching chronology: Most eggs had already hatched when we began surveys on 3 June (Table SC010-19). The first burrow from which a chick had fledged was recorded on 20 June. Fledging had occurred from over half the burrows investigated between 16 and 23 July.

Nocturnal behavior: Birds generally began flying into nesting slopes around 2250 h, and were heard calling as early as 2320 h, though main chorusing occurred later. In 1989, chorusing was intense after midnight during June and early July, but was reduced by the middle of July, when many chicks had fledged.

Comparison with past surveys:

1977:1989. The breeding population of Cassin's Auklets on Triangle Island in 1977 was estimated to be 359,000 pairs (Vermeer *et al.* 1979). Density ranged from 0.1 to 1.1 breeding pairs per m^2. The estimate for 1989 indicates a substantially larger population. We recalculated burrow density and occupancy from original data collected in 1976 and 1977 to allow statistical comparisons between years (Table SC010-20). Only data for the main side slopes which were sampled systematically in both years were used in density comparisons (Table SC010-21).

Overall mean densities of burrow entrances per m^2 ($\pm$ 1 S.E.) in the five areas used for comparisons were 1.26 $\pm$ 0.10 in 1977 and 1.36 $\pm$ 0.05 in 1989. Densities ranged from 0 to 4.72 in 1977 and from 0 to 5.25 in 1989. The 95% confidence limits of the means were 1.06 to 1.46 in 1977 and 1.26 to 1.46 in 1989. Results of Kruskal-Wallis tests showed no significant differences in density of burrow entrances between 1977 and 1989 (Table SC010-22).

Occupancy rates were calculated to be 62.0 $\pm$ 1.7% in 1977 and 75.0 $\pm$ 3.1% in 1989. Different sampling schemes were used to determine rates in the two years. Plots of fixed size were used in 1977, whereas in 1989 the number of burrows per sample was fixed. A total of 287 burrows were sampled in eight 25 m^2 plots in 1977 (Table SC010-23), and 260 burrows were sampled in 50 plots in 1989. Results of a *z* test showed that differences in occupancy rates between years were highly significant (Table SC010-24).

The breeding population estimate in 1989 exceeded that from 1977 by 53%. Differences in occupancy rates accounted for 21% of that difference. Estimates of colony area in the two years were similar, though slightly lower in 1989 - 97.6 ha in 1977, and 93.3 ha in 1989 - and did not contribute to the apparent increase. The remainder of the difference between the two estimates is attributable to the extrapolation of different density classes to various areas of the colony. More intensive sampling in 1989, especially across the top and on the north and east sides of the main island, and across Puffin Rock, provided a better resolution of colony boundaries and burrow densities. Unexplored areas assigned to lower density classes in 1977, were found to have higher densities when surveyed in 1989.

1984:1989. Cassin's Auklet burrow densities in Rhinoceros Auklet colony area in the south bay were compared between 1984 and 1989. Data from plots within Rhinoceros Auklet colony along 1989 transects 20 to 30 and T-3 to T-6 (Table SC010-17), which sampled the same areas as those sampled in 1984 (Table SC010-16), were used in the comparison. Mean densities in that area were 0.26 $\pm$ 0.05 burrows/m^2 (N = 26; plots 25 m^2) in 1984 and 0.32 $\pm$ 0.02 burrows/m^2 (N = 283; plots 4 m^2) in 1989. Differences were not significant (Kruskal-Wallis test: p = 0.87).

(text continues on page 49)

Table SC010-19. Contents of Cassin's Auklet burrows determined in occupancy plots on Triangle Island in 1989. If less than 5 burrows occurred in a plot, closest burrows outside the plot were added until there were at least 5 in the sample.

Date Day	Mon	Trans	Plot	Burrows in plot	Total sample	Contents Empty	Adult + egg	Cold egg	Adult +chick	Chick	Fledged chick	Total occupied
3	Jun	2	16	4	5		2			3		5
3	Jun	5	7	3	5	3	1			1		2
3	Jun	6	8	2	6	3				3		3
4	Jun	10	7	8	5	1			1	3		4
8	Jun	25	8	1	5	2	1			2		3
9	Jun	27	8	1	5				2	3		5
9	Jun	34	9	2	5	2	2			1		3
9	Jun	43	11	9	5				1	4		5
10	Jun	45	13	7	5	1	1			3		4
10	Jun	46	4	8	5				2	3		5
15	Jun	46	29	15	7	3				4		4
15	Jun	47	16	7	5		1			4		5
15	Jun	49	7	0	5		1		2	2		5
16	Jun	P-3W	5	6	5		1			4		5
16	Jun	T-3	3	1	5	1		1		3		4
18	Jun	T-6	5	2	5	3			1	1		2
20	Jun	T-7	6	1	5	2	1			1	1	3
22	Jun	T-9	7	3	5	2				3		3
23	Jun	T-15	7	3	5				1	4		5
24	Jun	T-19	9	3	5	1				4		4
24	Jun	T-22S	7	2	5	2				3		3
24	Jun	77	4	14	5		1			4		5
25	Jun	T-30	18	5	5					4	1	5
25	Jun	T-31W	21	7	5	1				2	2	4
26	Jun	T-32E	7	1	5	2	1			2		3
27	Jun	T-33W	13	2	5	2			1	2		3
27	Jun	T-33W	51	5	5	4				1	(dead)	1
28	Jun	52	3	7	5	2				3		3
29	Jun	53	6	4	5	1				1	3	4
29	Jun	T-34W	3	3	5	1				3	1	4
29	Jun	T-35W	3	3	5					2	3	5
4	Jul	T-35W	41	2	5	1			1	3		4
5	Jul	14	10	7	5	1		1		2	1	4
7	Jul	P-4	26	6	5				1*	2	2	5
7	Jul	T-35E	8	4	5				1*	1	3	5
7	Jul	72	6	12	5					3	2	5
8	Jul	T-36E	46	4	5	2		2		1		3
8	Jul	24	34	3	6	4				2		2
9	Jul	28	11	3	5	3				2		2
9	Jul	T-37E	19	10	5	1	1			2	1	4
9	Jul	T-37W	12	1	5	2				2	1	3
10	Jul	70	4	7	5	1				2	2	4
10	Jul	66	2	3	5					4	1	5
11	Jul	T-39	15	3	9	4					5	5
11	Jul	T-44	2	2	5						5	5
12	Jul	68	17	4	6	2				4		4
16	Jul	T-42	3	9	5						5	5
19	Jul	56	15	4	6	3				1	2	3
20	Jul	58	15	4	5	1				2	2	4
23	Jul	19	8	10	5	1	1			3		4
			Total	237	260	65	15	4	14	119	43	195

* Only adult was felt.

Table SC010-20. Calculations used to derive Cassin's Auklet population estimate on Triangle Island in 1977.

Location	Plots: No. in Sample	Plots: Area (m^2)	Plots: % of Locat'n	Plots: Occup'd Bur/m^2	Location: Area (ha)	Location: % of Colony	Location: Population[1]
Side Slopes							
South Bay							
-E (1976)	38	950	1.28	.22	7.4457	7.63	16,327
-W grass	10~	-	-	.922~	1.3425*	1.37	13,318
-W salmbry	14~	-	-	.369~	1.0215*	1.05	3,769
West Bay	32	800	.73	.881	10.9329	11.20	96,346
Between W & NW Bays	0	-	-	.544~	2.5000	2.56	13,600
NW Bay	17	425	.81	.544	5.2289	5.35	28,421
NE Bay & N Slopes							
-Fern	5~	-	-	.511~	1.3219*	1.35	6,755
-grass/salmbry	8~	-	-	.631~	6.0687*	6.21	38,293
-upper grass with puffins	7~	-	-	.328~	1.8320*	1.88	6,009
East side	7~	-	-	.328~	2.7959*	2.86	9,171
Interior slopes: all plots 40m from outer ridges, except for transect along the Saxifrage Ridge and some interior facing ridge plots on the SE peninsula.							
Saxifrage Ridge N from peak							
-Salmonberry	6	150	1.35	.093	1.1150	1.14	1,035
-Saxi/fern/etc	9	225	1.23	1.06	1.8269	1.87	19,406
SE Peninsula	8	200	1.01	.799	1.9880	2.04	15,904
E of Saddle Cr	9	225	.47	.085	4.7600	4.87	4,062
W of Saddle Cr to Saxifrage Ridge Sb	5	125	.23	.115	5.3350	5.46	6,146
E of Saxifrage Ridge Sax/frn/	9~	-	-	.021~	5.7773	5.92	1,213
W of Saxifrage Ridge							
-SW Salmbry	6	150	.42	.365	3.5363	3.62	12,900
-C & NW Salmb	9	215	.10	.022	21.7561	22.28	4,857
-Saxifrag/fern	4	100	.38	.706	2.6500	2.71	18,698
-Fern	2	50	1.56	.499	.3210	.34	1,602
Puffin Rock	12	327	.98	.119	3.3383	3.42	3,969
Ridges above side slopes							
South Bay	14	350	1.91	.866	1.8356	1.88	18,579**
W & NW Bays	14	337.5	2.01	.747	1.6817	1.72	12,970**

cont'd...

Table SC010-20. (cont')d

Location	Plots: No. in Sample	Plots: Area (m^2)	Plots: % of Locat'n	Plots: Occup'd Bur/m^2	Location: Area (ha)	Location: % of Colony	Population[x]
North End							
-West	7	175	6.41	.450	.2730	.28	1,536**
-W Central	2~	-	-	.278~	.0750	.08	209
-E Central	6~	-	-	.424~	.1750	.18	742
-East	15~	-	-	.863~	.1350	.14	1,165
NE Bay							
-West	5	125	5.26	.177	.2376	.24	420
-East	4	100	4.21	.350	.2375	.24	832
NE Corner	2	50	4.90	.605	.1020	.10	694**
Ttl or mean	203 83~	5081.5	.52	.368	97.6463	100.	358,948

[x] Except as indicated below, population calculated by:

$$P = \frac{\text{Entrances}}{\text{Total sample plot area } (m^2)} \times \text{location area } (m^2) \times .48 \text{ occupied burrows/entrance}$$

~ No sample plots were done in those locations. "Representative" plots from other locations were used to determine density of occupied burrows. Population calculated by:

P = location area x mean occupied burrow density in plots used.

* Amount of slope judged to be suitable habitat.

** For those ridge areas the population was calculated by:

P = Sum(nwl/a) x .48 occupied burrows/entrance

Where:

n = number of entrances in plot
w = ridge habitat width at plot (m)
l = length of ridge top from mid-point between adjacent plots, or to edge of measured habitat for end plots (m). Inter plot spacing was generally 70 m.
a = area of sample plot (m^2)

The population calculated this way was always larger than that obtained using the first formula above.

Table SC010-21. Plot data for locations used in the comparison of Cassin's Auklet burrow entrance density on Triangle Island between 1977 and 1989. In 1977, burrows in each plot were not explored to differentiate starts or multiple entrances, and only total burrow entrances were recorded. Total entrances were then corrected to numbers of burrows and occupied burrows from ratios determined in occupancy plots. We added second entrances and starts over 15 cm to the number of burrows recorded in each plot in 1989 to make counts comparable to 1977.

Location	Year	No. of plots	Area sampled (m^2)	Entrances/m^2			
				Mean	Std Dev	Min	Max
South Bay, E slopes	1977	38	950	0.45	0.69	0	2.84
	1989	185	740	0.42	0.50	0	2.25
West Bay	1977	32	800	1.92	1.27	0.08	4.72
	1989	246	984	1.84	1.43	0	5.25
North-west Bay	1977	17	425	1.14	0.75	0.04	2.6
	1989	108	432	1.59	0.88	0	3.5
South Ridges	1977	12	300	1.95	0.74	0.76	2.96
	1989	26	104	1.81	1.11	0	3.75
West Ridges	1977	14	337.5	1.50	0.71	0.40	3.0
	1989	22	88	1.84	0.71	0.25	3.0
Total	1977	113	2812.5	1.26	1.09	0	4.72
	1989	587	2348	1.36	1.24	0	5.25

Table SC010-22. Results of Kruskal-Wallis tests comparing Cassin's Auklet burrow entrances per m^2 on Triangle Island between 1977 and 1989. Areas were tested individually and combined.

Areas combined:	
Test statistic (t)	0.0390625
Chi-square approximation:	
Degrees of freedom	1
Prob(x > .0390625)	0.8433
Sum of individual areas:	
East half of South Bay slopes	
Test statistic (t)	7.324219E-04
Chi-square approximation:	
Degrees of freedom	1
Prob(x > 7.324219E-04)	0.9784
West Bay slopes	
Test statistic (t)	0.2890625
Chi-square approximation:	
Degrees of freedom	1
Prob(x > .2890625)	0.5908
North-west Bay slopes	
Test statistic (t)	3.781525
Chi-square approximation:	
Degrees of freedom	1
Prob(x > 3.781525)	0.0518
South Ridges	
Test statistic (t)	9.862518E-02
Chi-square approximation:	
Degrees of freedom	1
Prob(x > 9.862518E-02)	0.7535
West Ridges	
Test statistic (t)	2.038605
Chi-square approximation:	
Degrees of freedom	1
Prob(x > 2.038605)	0.1534
Sum of t for all areas	
Sum of t (T)	6.2085501019
Chi-square approximation:	
Degrees of freedom	5
Prob(x > 6.208550)	0.713548

Table SC010-23. Number of occupied Cassin's Auklet burrows per 25 m^2 plot on Triangle Island in 1977.

Plot No.	Entrances	Burrows	Occupied Burrows
1	58	37	21
2	21	18	11
3	56	47	27
4	13	10	7
5	80	66	44
6	69	63	40
7	40	24	15
8	32	22	13

Table SC010-24. Comparison of Cassin's Auklet burrow occupancy rates (R) determined on Triangle Island in 1977 and 1989.

Parameter	1977	1989
Size of plot (m^2)	25	4~
Number of plots (n)	8	50
Total burrows sampled	287	260
Mean of occupied burrows per plot ($\bar{x}_o$)	22.25	3.90
Standard deviation (s_o)	13.67741	1.05463
Coeficient of Variation = $s_o/\bar{x}_o$	0.6147	0.2704
Mean of Total Burrows ($\bar{x}_t$)	35.875	5.2
Standard Deviation (s_t)	21.01328	0.670059
Coeficient of Variation = $s_t/\bar{x}_t$	0.5857	0.1289
Ratio of o/t (R) = $\bar{x}_o/\bar{x}_t$	0.6202	0.75
Correlation Coeficient of o vs. t (r)	0.9932	0.0289
Variance of R (V)	0.0002758	0.0009867
Standard Error of R	0.0166	0.0314
95% Confidence limits of R	0.58 <--> 0.66	0.69 <--> 0.81
99% Confidence limits of R	0.56 <--> 0.68	0.67 <--> 0.83

$$z = \frac{R_{89} - R_{77}}{(V_{89} + V_{77})^{1/2}} = 3.6528; \quad p < 0.00001$$

~ > 4 m^2 if < 5 burrows in plot.

Rhinoceros Auklet: 1982: No data were collected on numbers of breeding birds in 1982. Observations of nocturnal behavior are summarized below.

1984: All areas in the south bay and on the southeast ridge were explored in 1984 to determine Rhinoceros Auklet colony boundaries and appropriate placement for transects. Other parts of the island were not thoroughly explored.

Rhinoceros Auklets were nesting on all slopes in the eastern half of the south bay, but were absent from most dense salmonberry habitat on the west end of the bay. Burrows were most abundant on steep Tufted Hairgrass slopes, but were frequent amongst short salmonberry. Slopes within colony areas ranged from 18 to 53° and averaged 36° (Table SC010-1). In the central portion of the south bay, Rhinoceros Auklet burrows petered out and Cassin's Auklet burrows became more abundant at the crest of steep slopes where topography rounded onto the level interior of the island. In Calamity Cove, burrows continued above side slopes and extended throughout the draw on the southeast ridge (Fig. SC010-3; Table SC010-25).

Table SC010-25. Number of Rhinoceros Auklet burrows in 5x5 m plots along transects on Triangle Island in 1984. Plots considered outside the colony are indicated by a dash.

	Transect										
Plot	1	2	3	4	5	6	7	8	9	10	11
1	1	28	2	9	1	0	-	-	-	0	2
2	27	14	13	4	22	14	-	0	27		
3		14		12		12		2	1		
4		13				14			15		
5		13				22			9		

Corresponding to the density of burrows in different habitats, most burrow entrances occurred under grass tussocks, with fewer found under shrubbery, rock and forbs (Table SC010-26).

During exploration of burrows to determine occupancy, we identified nest-cup material in 60 burrows (Table SC010-27). Grass was the most common material, but leaves of salmonberry, salal, and *Maianthemum* also were encountered.

Table SC010-26. Habitat locations of Rhinoceros Auklet burrow entrances on Triangle Island in 1984.

Burrow locations	Number of burrows	Percent
Grass tussock	213	73
Shrubs-salmonberry	54	19
Shrubs-salal	9	3
Rock	6	2
Forbs	5	2
Open ground	3	1
Total	290	

Lengths of a sample of 95 burrows ranged from 0.4 to 3.0 m and averaged 1.0 ± 0.5 m (S.D.).

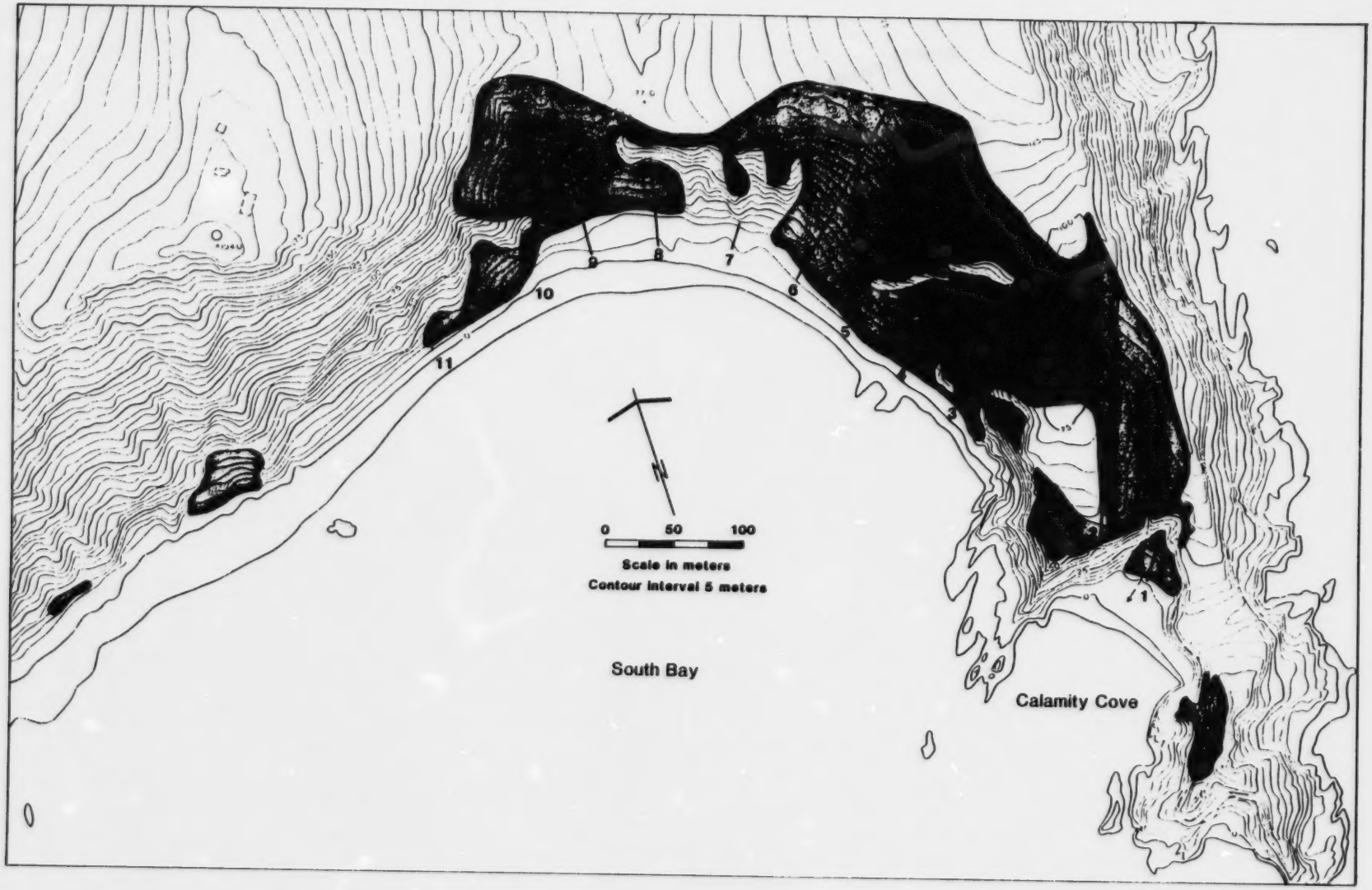

Figure SC010-3. Rhinoceros Auklet colony and transect locations in the south bay of Triangle Island in 1984.

Breeding chronology and success: Most chicks had hatched when the survey began in 1984 (Table SC010-28). The latest incubating bird was recorded 13 July. Results of inter-year comparisons in nestling growth rates between 1984 and 1986, indicate that hatching was delayed, and chick growth was retarded in its later phases in 1984 (Bertram and Kaiser 1988).

Table SC010-27. Rhinoceros Auklet nest cup contents on Triangle Island in 1984.

Materials	Number of burrows	Percent
Grasses	40	67
Salal leaves	4	7
Salmonberry leaves	7	12
Grass and maianthemum	6	10
Grass, maianthemum and salmonberry	1	2
Nothing	2	3
Total	60	

Table SC010-28. Occupancy of Rhinoceros Auklet burrows along transects, in growth study plot and permanent monitoring plots on Triangle Island in 1984. Contents of burrows in permanent plots were only incidentally determined and were not included in calculations of occupancy rate.

Date	Location Tran	Plot	Empty	Adult + egg	Adult	Chick	Dead chick	Unknown	Total occup	Total known
11/07	4	1				2		7	2	2
11/07	4	3		2				10	2	2
11/07	6	2	2			3		9	3	5
11/07	6	3	1			4		9	4	5
11/07	6	4				3		11	3	3
11/07	6	5				5		17	5	5
13/07	9	2	3			6	1	17	7	10
13/07	9	4	2					13	0	2
13/07	9	5	1	1				7	1	2
19/07	1	1				1			1	1
19/07	1	2	2			4		21	4	6
19/07	2	1	2			2		24	2	4
19/07	2	3	2			1		11	1	3
08/07	Growth plot		37	5		54	1	21	60	97
Total for calculation			52	8		85	2	177	95	147
Perm. plot quadrat										
15/07	2	1	2			1		8	1	3
15/07	2	2	2			2		12	2	4
15/07	2	3				1		14	1	1
15/07	2	4	3					10	0	3
16/07	1	1	1					6	0	1
16/07	1	2			1	2		5	3	3
16/07	1	3				1		2	1	1
16/07	1	4				1		4	1	1
Overall totals			60	8	1	93	2	238	104	164

1984 Population estimate: (South bay)

Number of sample plots:	26 (650 m^2 - 0.7% of colony)
Average density:	4,477 ± 693 burrows/ha
Colony area:	8.7 ha
Total burrows:	38,893 ± 6,019
1984 Occupancy rate:	64.6 ± 2.9% (95 of 147 known)
1984 Nesting population:	25,125 ± 4,045 pairs

1985: As in 1984, most chicks had hatched when we began the growth study. Adults were still incubating in only five of 54 occupied burrows checked between 11 and 14 July. One fledged chick was recorded on the last night of the study period on 24/25 July.

1989: The entire island was explored and transected in 1989, and Rhinoceros Auklets were found nesting over a larger area than in 1984 (Fig. SC010-4). Colony area in the south bay in 1989 extended further up the ridge line towards the lighthouse and further along the east side of the island than that mapped in 1984. Burrows were abundant across a narrow strip of habitat in the low draw above Calamity Cove where we had not observed them in 1984. We also encountered nesting areas in the northeast bay that we had not discovered on previous surveys (see below).

Table SC010-29. Habitat locations of Rhinoceros Auklet burrow entrances on Triangle Island in 1989.

Burrow locations	Number of burrows	Percent
Grass tussock	516	62.0
Shrubs	207	24.8
Into bank	42	5.0
Open ground	32	3.8
Fern	24	2.8
Rock	7	0.8
Forbs	3	0.4
Dead crabapple roots	1	0.1
Total	832	

As in 1984, most burrows occurred in grass, but were found as far as 50 m into tall, dense salmonberry habitat along steep, south slopes, and as far as 10 m into similar vegetation on moderate, interior slopes above the south bay. Locations of burrows entrances indicate similar habitat use to that recorded in 1984 (Table SC010-29).

Burrow lengths were similar to that found in 1984, ranging from 0.4 to 2.0 m and averaging 1.0 ± 0.4 m (N = 63).

Burrow density was significantly higher in the south bay and southeast ridge than in the northeast bay (Kruskal-Wallis test: $p < 0.05$).

Intermittent data from occupancy plots indicated that birds were incubating at the beginning of June, most chicks had hatched by the end of June, and chicks were fledging at the end of July and beginning of August (Table SC010-30). The first sandlance (*Ammodytes hexapterus*) dropped by adults on nesting slopes was found on 14 June. Scant evidence

suggests that hatching was earlier in 1989 than in 1984 or 1985. Except for one cold egg, 13 burrows investigated on 7 July all held chicks. In 1984 and 1985, there were some adults still incubating in the second week of July.

Table SC010-30. Occupancy of Rhinoceros Auklet burrows along transects on Triangle Island in 1989.

Date	Location Tran	Location Plot	Empty	Adult + egg	Cold egg	Adult	Chick	Fledged chick	Total occup	Total known
09/06	2	16		3		1			4	4
23/06	19	8					2		2	2
23/06	T-3	3	2	1			2		3	5
24/06	T-5	2	2	2			3		5	7
24/06	T-9	7					1		1	1
07/07	T-34E	1					2		2	2
07/07	T-35E	28	1				3		3	4
07/07	73	29					1		1	1
07/07	73	36					1		1	1
07/07	72	14					1		1	1
07/07	T-36E	15	1		1				2	2
07/07	T-36E	16	1				1		1	2
04/08	23	5	3				3		3	6
04/08	25	8	4				1	1	2	6
04/08	27	8	2				1	3	4	6
	Totals		16	6	1	1	22	4	34	50

1989 Population estimate:

Number of sample plots:	South bay:	325 (1300 m^2 - 1.3% of colony)
	Northeast bay:	54 (216 m^2 - 1.6% of colony)
	Total:	379 (1516 m^2 - 1.4% of colony)
Average density:	South bay:	5,769 ± 272 burrows/ha
	Northeast bay:	3,842 ± 195 burrows/ha
	Overall:	5,494 ± 245 burrows/ha
Colony area:	South bay:	9.8 ha
	Northeast bay:	1.4 ha
	Total:	11.2 ha
Total burrows:	South bay:	56,451 ± 2,662
	Northeast bay:	5,270 ± 268
	Overall:	61,297 ± 2,733
1989 Occupancy rate:		68.0 ± 6.2% (34 of 50 known)
1989 Nesting population:		41,682 ± 4,216 pairs

Comparison between surveys: Rhinoceros Auklets appear to have expanded on Triangle Island in the last 40 years. They were not found nesting in 1949, though large numbers of birds in breeding plumage were observed off the south bay, and nesting was suspected in inaccessible areas (Carl *et al.* 1951). An extensive colony was present in the south bay in 1966 (Hancock 1970), and, from descriptions, was similar in extent to that reported in 1976 (Vermeer 1979). Vermeer (1979) estimated 15,000 pairs of Rhinoceros Auklets nesting on Triangle Island in 1976. Original data from that survey were not available and statistical comparisons between 1976 results and those from 1984 or 1989 were not possible. Comparing available population parameters suggests colony expansion between 1976 and 1984. Colony area was estimated to be 7.4 ha in 1976 (Vermeer and Summers unpubl.) and 8.7 ha in 1984. No burrows were found in Calamity Cove or on the southeast ridge in 1976 (Vermeer 1979, pers.comm.). Burrow density averaged 4,166 burrows/ha in 1976 (N = 38 plots, 5x5 m^2) and was similar to that determined in 1984. Occupancy rate was 43% (N = 109) in 1976, lower than rates calculated in 1984 and 1989. Reproductive success was low in 1976 (Vermeer 1978) and may account for the low occupancy rate.

The 1989 population estimate exceeded that from 1984 by 16,600 pairs (66% of the 1984 estimate). Some of that increase may be due to more intensive exploration and survey methodology in 1989, but a portion may represent actual population change.

Colony areas in the south bay were thoroughly explored in 1984 and 1989, and we believe that recorded differences in colony extent indicate colony expansion (Fig. SC010-3 and 4). We were unable to detect differences in upper boundaries of the colony above the main south slopes, but the extent of Rhinoceros Auklet burrows along the ridge line east of the lighthouse, and on the east side of the island was greater in 1989 than that mapped from explorations in 1984. Those extended areas added 1.1 ha (13%) to the colony area mapped in the south bay in 1984.

We are less certain that observations made in the northeast bay indicate expansion. We found considerable area of colony there in 1989 that we had not recorded previously. However, Vermeer and Summers (unpubl. 1979) reported a newly established colony in that area in 1977, which they had not observed in 1975. Summers (unpubl.) counted 3,300 birds flying from slopes in the northeast bay on the morning of 28 July 1977. Birds were flying from the same areas as those mapped as colony in 1989. The museum party camped in the northeast bay and saw no evidence of nesting in 1949 (Carl *et al.* 1951). The area was explored in 1982 during a survey for Tufted Puffins (see below), and no evidence of Rhinoceros Auklets was reported. In 1984, exploration of that area was hindered by fog and lack of time. Surveillance of the northeast bay was kept on the evenings of 14 and 22 July 1985, to determine if Rhinoceros Auklets were staging or flying into nesting slopes. An estimated 900 birds gathered in the bay at 2130 h on 14 July, and over 500 were staging there at the same time on 22 July. Some flocks flew around the east side of the island, probably to the south bay, after 2130 h, but none were seen circling or landing on slopes above the northeast bay. Birds may have begun circling after 2200 h when it was too dark to continue observations, though large flocks began circling the south bay that night at 2130 h.

It is possible that Rhinoceros Auklets were not nesting in the northeast bay between 1982 and 1985, but our observations during those years are inconclusive. The best exploration of the area prior to 1989 was conducted in 1982, but the focus of that survey was Tufted Puffins, and Rhinoceros Auklets could have been overlooked. Estimates in 1989 (3,600 pairs) and 1977 (1,500 pairs - Vermeer 1979) suggest that the colony in that area has expanded.

Changes in burrow density and occupancy rates also may account for larger population estimates in 1989. Occupancy rates were similar in 1984 and 1989: 64.6 $\pm$ 2.9% and 68.0 $\pm$ 6.2% respectively ($z = 0.497$; $p = 0.31$). Burrow density was higher in 1989 than in 1984, though differences were not significant. Overall density was 4,477 $\pm$ 693 burrows/ha in 1984 and 5,494 $\pm$ 245 burrows/ha in 1989. Density in 1989 in the area surveyed in 1984 was 6,531 $\pm$ 330 burrows/ha. That density was not significantly different than that

determined in 1984 (Kruskal-Wallis test: $p = 0.17$). Higher burrow density and occupancy rate in 1989 accounted for 29% and 8%, respectively, of the 66% increase in population estimates. Added colony area in the south and northeast bays accounted for the remaining 29%.

Staging and nocturnal behavior: The arrival and departure routine of Rhinoceros Auklets was an anticipated spectacle every night on Triangle Island. Clouds of Rhinoceros Auklets circled and flew into nesting slopes in the middle of the south bay most evenings we were present in 1982, 1984 and 1985. Timing varied under different weather conditions - earlier on dark, cloudy or foggy nights - but generally followed the schedule outlined below.

Staging birds gathered on the water between 2000 and 2200 h. On 10 July 1985, we recorded 250 staging birds at 2015 h, increasing to 2200 birds by 2130 h. Numbers increased from 200 at 2000 h to 3800 at 2210 h on 12 July, and an estimated 5,400 were staging at 2150 h on 14 July.

Small circling flocks moving in and out of staging groups were frequently observed during the same period numbers of staging birds were increasing, but major wheels occurred later. Circling flocks increased in size after dusk, until flocks of over 1000 birds were wheeling hypnotically around the bay, gradually gaining elevation and approaching closer to nesting slopes. Major flights were clockwise around the bay, but there were always suicidal individuals flying counter-current. Head-on collisions were rare, but did occur. Birds usually recovered from such collisions before they hit the ground, though some fell stunned to the beach.

In an attempt to estimate the size of circling flocks, we timed the circling period of individual birds between 2210 and 2220 h on 14 July 1985. The rotation period of seven birds averaged 61 seconds (range: 40 to 113 seconds). Counting the number of birds passing within that interval indicated a flock size of 1900 birds.

Birds began landing on nesting slopes by 2200 h, but most landed under cover of darkness between 2230 and 2430 h. Single birds were still arriving until after 0300 h when the majority began to depart. Departures were most frequent between 0300 and 0430 h, but some birds were observed leaving until 0545 h, well after daylight.

Sporadic calls were heard after midnight on many nights, but the main period of vocalization on the slopes occurred after 0300 h, during the time birds were departing in large numbers. Calls were not heard from birds in flight or on the water.

Prior to 1989, we were present only in July, during the nestling period for Rhinoceros Auklets. In 1989, we had the opportunity to make observations over a more extended period. Evening staging and circling behavior changed through the breeding season. The first large circling flock was observed on 21 June, about the time chicks began to hatch. Earlier in June, flocks were generally less than 100 birds, often no more than 10. Flight paths were erratic at that time, compared to the consistent clockwise pattern observed later. Large flocks became more frequent towards the end of June, were regular during the second week of July, and were rare through the end of July and middle of August. In other years, large circling flocks were more frequent later in July than observed in 1989. This may relate to hatching chronology, which appeared to be earlier in 1989 than previous years.

Numbers of incoming birds increased from early June, during incubation, to July, when adults were feeding young. Many birds were flying straight into nesting slopes after the end of June, and steady streams of arriving birds flying straight in without circling were recorded from 16 July to 20 August.

We suspect that during the nestling period at least, most circling birds were nonbreeders. We observed few birds carrying fish in circling flocks; most birds with fish appeared to fly directly to nest sites.

Tufted Puffin: 1982: Surveys for Tufted Puffins were conducted in 1982 and 1989. Puffin population estimates were the sole objective of the 1982 survey, and puffin colony areas, especially on Puffin Rock, were sampled intensively (Tables SC010-31 and 32; Fig. SC010-5, 6 and 7). In 1989, survey design focused on Cassin's Auklets, and colony areas of other species were sampled at the same intensity deemed appropriate for Cassin's Auklets (Table SC010-17). The entire island was explored more thoroughly in 1989, but puffin colony was sampled at a much lower intensity than in 1982.

There were no indications of change in colony distribution from 1982 to 1989, and colony areas were considered identical. Explorations in 1989 provided finer resolution of colony boundaries on the main island than obtained in 1982, and maps drawn in 1982 were refined accordingly. Measurements of colony area on Puffin Rock in 1982 were considered accurate and were used to map colony in both years (Fig. SC010-5).

Puffins were nesting sporadically over large portions of the island (Fig. SC010-4). We did not attempt to measure colony area or burrow density for those scattered pairs. As many of those locations are not safely accessible, and because burrows there are too sparse to sample effectively with normal transect methods, they are unlikely to be considered in future comparisons, and we have not included them in our calculations of nesting populations.

In the south bay, scattered puffin burrows were encountered along transects in the vicinity of steep rocky ribs, and birds were frequently seen flying into ridge lines on steep salmonberry slopes below the old lighthouse. Some birds flew into tall salmonberry habitat as low as 20 m elevation, but most landed on exposed edges of rocky ribs high on the slopes. Sporadic burrows also occurred across upper grassy slopes in the west bay, and in patches of vegetation on rock bluffs along the east side of the island that were too small or discontinuous to map.

Most puffin burrows occurred in Tufted Hairgrass, and only incidental burrows were located in other habitats. On Puffin Rock, burrows occurred on all Tufted Hairgrass slopes with sufficient soil to support burrows. A small nesting area occurred under large boulders just above the shore on the northeast side. Burrowing occurred on slopes ranging from 10° to 59° and ended where the slopes levelled.

On the east side of the main island, puffins nested in Tufted Hairgrass as well as on fringes of salmonberry, lady fern and crabapple. Burrows were found on slopes ranging from 37° to 50°. Large numbers of puffins were seen flying around and sitting on slopes on the west side of the northeast bay. Major concentrations occurred on Tufted Hairgrass slopes on the northeast corner, opposite Strata Rock, and on the Impasse ridge.

Separate average burrow density estimates were calculated for colony areas on Puffin Rock and the main island, because sampling was more systematic, intensive and replicable on Puffin Rock than in other areas. On Puffin Rock, transects were placed by measuring intervals along the perimeter, whereas on the main island, transects were run where topography permitted. Mean burrow density on Puffin Rock was 67% higher than on the rest of the island, though differences between the two areas were not quite significant (Kruskal-Wallis test: $p = 0.0557$).

Occupancy rate on Puffin Rock in 1982 was significantly higher than that estimated for other areas ($z = 1.7701$; $p < 0.05$). Higher burrow density and occupancy rate on Puffin Rock suggests that it is the preferred area for puffins on Triangle Island.

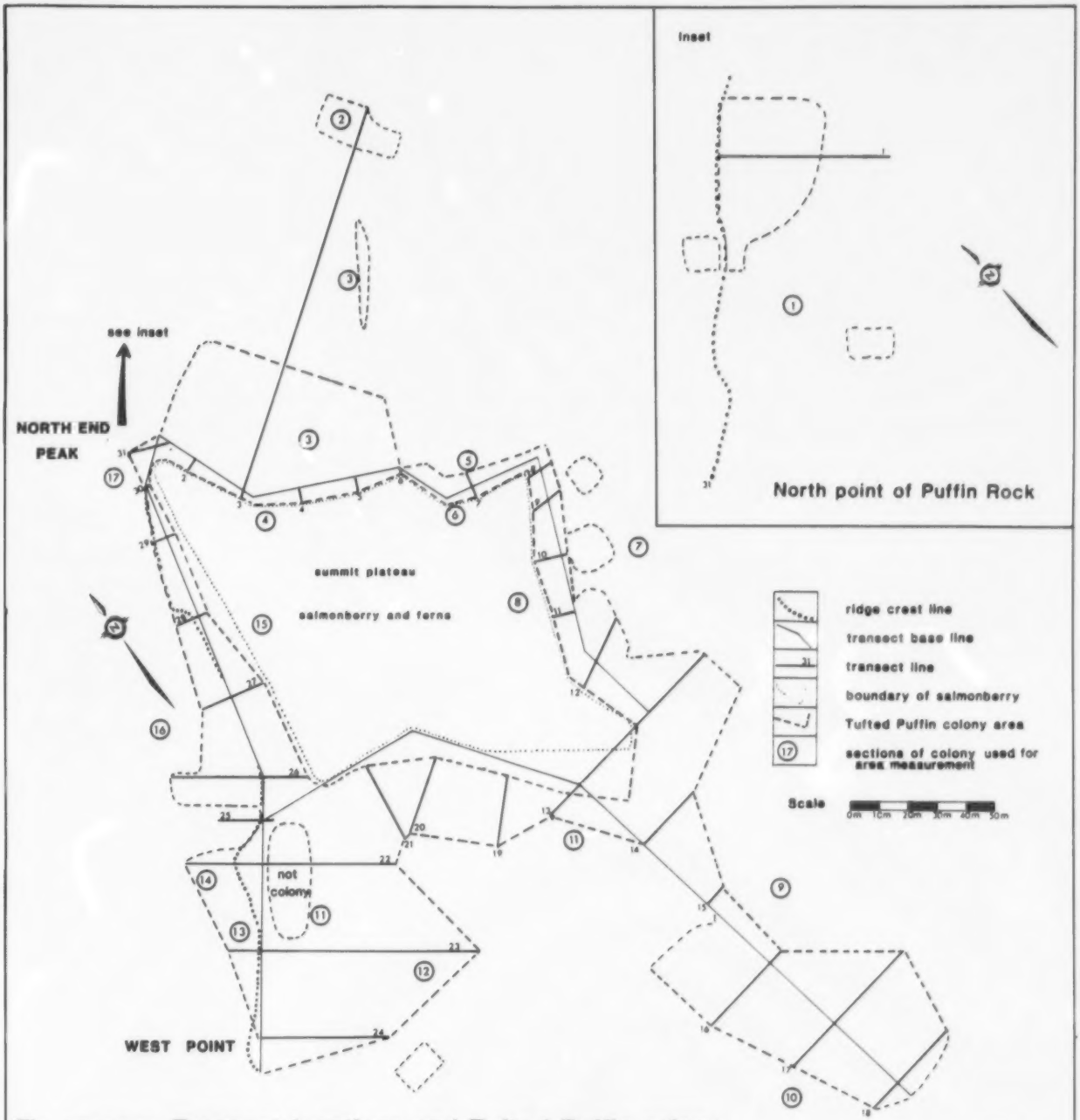

Fig. SC010-5. Transect locations and Tufted Puffin colony on Puffin Rock in 1982

Planar representation based on field measurements

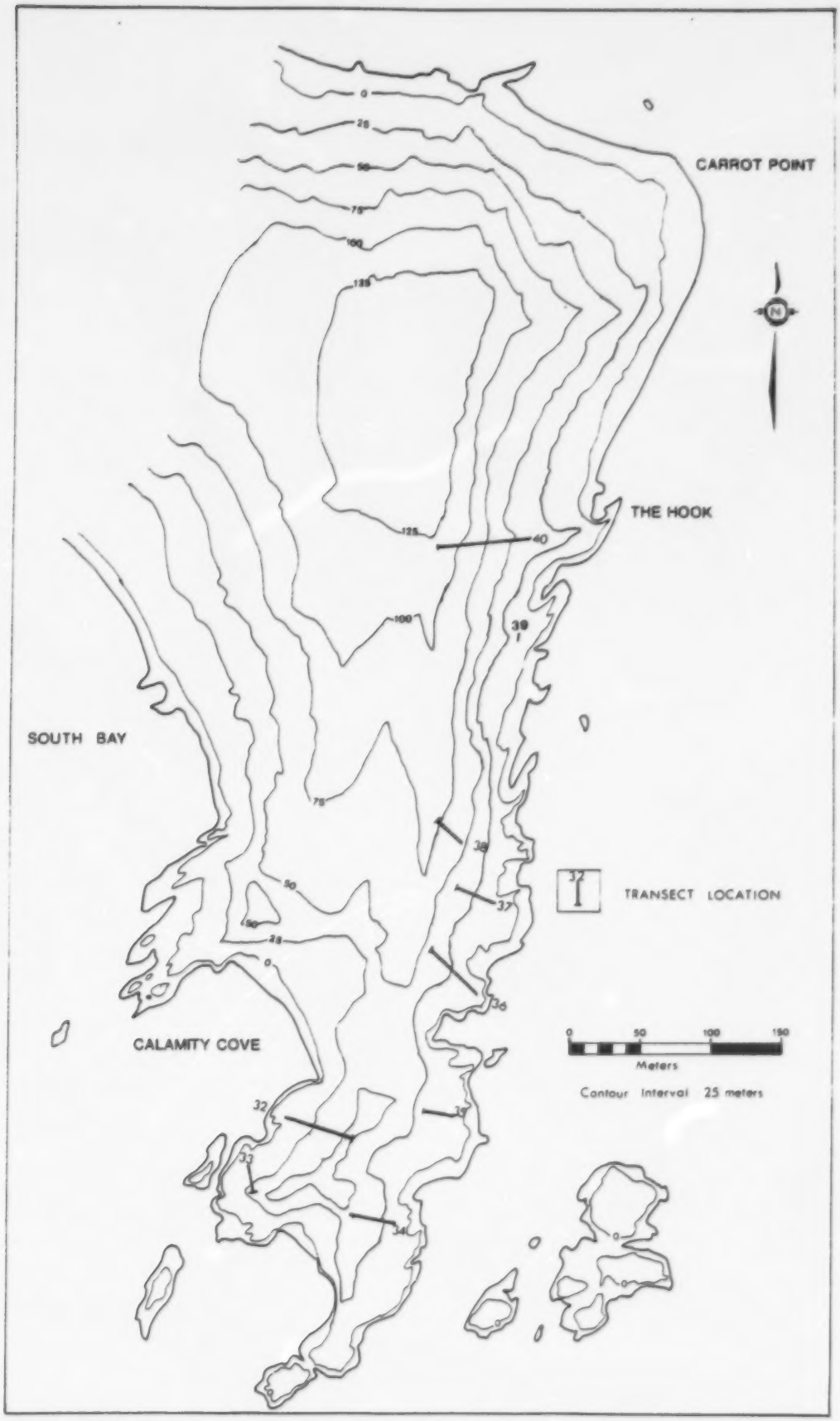

Figure SC010-6. Transect locations on the east side of Triangle Island in 1982.

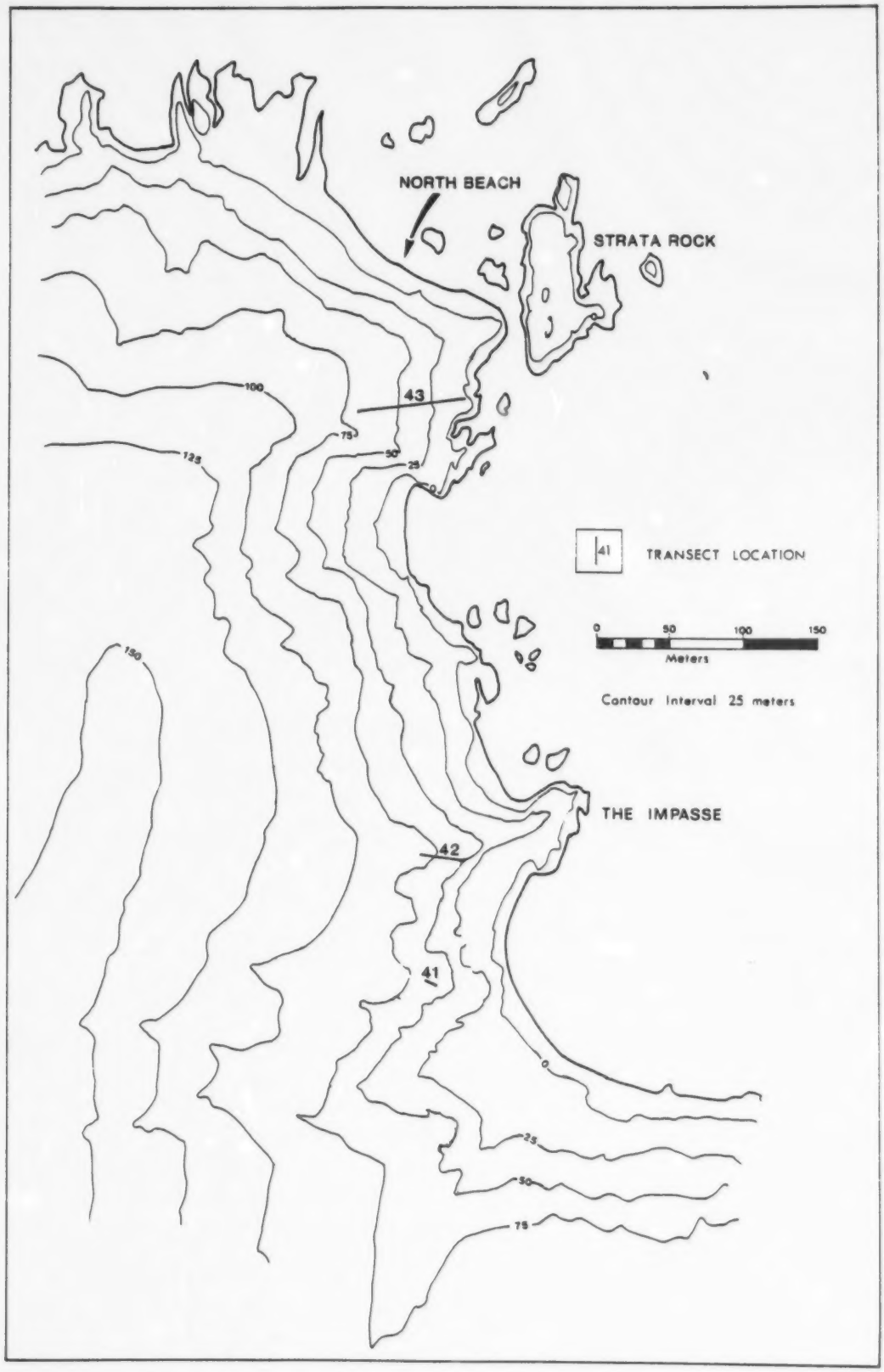

Figure SC010-7. Transect locations in the northeast bay of Triangle Island in 1982.

Table SC010-31. Number of Tufted Puffin burrows in 5 m segments along 3 m wide transects on Triangle Island in 1982. Plots considered outside colony areas are indicated by a dash.

	Transect and Bearing																					
Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Bearing(°)	315	270	233	205	205	250	193	274	267	294	294	215	260	260	260	260	260	260	224	235	188	307
Baseline on Puffin Rock intersected at: (m)	61	0	141	0	0	5	5	3	5	2	1	16	28	25	8	6	35	25	30	34	31	46
Plot	Number of burrows																					
1	-	7	1	0	0	8	3	3[c]	7	3[b]	0[a]	1[a]	10[c]	10	3	1	10	4	7	18	4	14
2	-	-	2			2[a]	2[d]	5	12	20	10	8	25	19	0[c]	5	7	4	15	11	4	19
3	-		1						1[b]	9	2[d]	5	15	21		1	14	11	18	7	11	14
4	-		-							0		6	23	20		17	13	9	15	5	18	19
5	-		-									13	21	2		29	8	8	7	3	21	15
6	1		-									2	18			24	12	16		4[c]	6[d]	4[c]
7	2		-									0[c]	17			19	6	14		-		-
8	10		-										5[b]				4	1[b]				-
9	11		-										-				1					-
10	10		-										-				17					7
11	8		-										-				12					13
12	0		-										1[a]									8
13			-										28									0
14			-										25									0
15			-										-									1[c]
16			-																			
17			-																			
18			-																			
19			-																			
20			1																			
21			5																			
22			10																			
23			6																			
24			7																			
25			3																			
26			3																			
27			4																			
28			2																			
29			4																			
30			0																			

cont'd

Table SC010-31. (cont'd)

Transect	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Bearing(°)	307	307	307	307	104	104	104	104	113	108	175	280	279	314	288	306	180	264	290	277	251
Baseline on Puffin Rock intersected at: (m)	75	45	15	32	12	7	0	0	15												

Plot	Number of burrows																				
1	1	1	-	3	12	6	10	1[d]	-	-	-	-	1	-	2[d]	11	-	6	4[d]	11	1
2	5	2	-	3	20	8	5[c]		2	-	-	-	0	-	4	11	-	9	6	15	8
3	1	5	-	19	16	6[b]			1	1	-	-	1	1[a]	2	7	3[c]	10		5	7
4	1	4	8	23	9				11	0	-	6	0	3	6	9	12	8		6	9
5	5	8		17	7[d]					2	-	4	-	3	1	12		12		14	9
6	0	10		10						3	1[a]	4	-	2	4	10		8		6	6
7	0	12		13						7	2	3	-	3	7	10[b]		5		1	0
8	5	14		17						7	3	5	-	6				0		3	6
9	6	16		7						7	1	8		6				0		1[a]	10
10	18	1[c]		1[c]						4	0[b]	2		6				12		-	2
11	23									2				1[a]				4			
12	16									2								10			
13	13									1								11			
14	3									-								3			
15	1									-								7			
16	10																	8			
17	9																	5			
18	1[b]																	7			
19																		2			
20																		1			
21																		2			
22																		13			
23																		3			
24																		6[d]			

a - plots are 1m x 3m
b - plots are 2m x 3m
c - plots are 3m x 3m
d - plots are 4m x 3m

Table SC010-32. Number of Tufted Puffin burrows per transect section used for density calculations on Triangle Island in 1982.

Transect section	Bearing (°)	Extent of colony (m)	Area sampled (m^2)	Burrows
Puffin Rock				
1	315	35	105	42
2	270	5	15	7
3a	233	15	45	4
3b	233	50	150	45
4	205	5	15	0
5	205	5	15	0
6	250	6	18	10
7	193	9	27	5
8	274	8	24	8
9	267	12	36	20
10	294	17	51	32
11	294	10	30	12
12	215	29	87	35
13a	260	35	105	134
13b	260	11	33	54
14	260	25	75	72
15	260	8	24	3
16	260	35	105	96
17	260	55	165	104
18	260	37	111	67
19	224	25	75	62
20	235	28	84	48
21	188	29	87	64
22a	307	28	84	85
22a	307	28	84	29
23	307	87	261	118
24	307	48	144	73
25	307	5	15	8
26	307	48	144	113
27	104	24	72	64
28	104	12	36	20
29	104	8	24	15
30	104	4	12	1
31	113	15	45	14
East slope				
32	108	55	165	36
33	175	18	54	7
34	280	35	105	32
35	279	20	60	2
36	314	37	111	31
37	288	34	102	26
38	306	32	96	70
39	180	8	24	15
40	264	119	357	152
North slope				
41	290	9	27	10
42	277	41	123	62
43	251	50	150	58
Total			3,828	1,965

Table SC010-33. Occupancy of Tufted Puffin burrows in 3x5 m plots along transects on Triangle Island in 1982.

Location		Contents of burrow								
Transect	Plot	Adult	Adult + egg	Warm egg	Adult + chick	Chick	Empty	Unknown	Total occupied	Total known
Puffin Rock										
1	40-45m			3		3	3	2	6	9
3	toothpick		2	2		2	6		6	12
6	0-5m			1	6		1		7	8
12	6-11m	1		1		1	2		3	5
16	15-20m					15	2		15	17
22	10-15m	1		1		7	5		9	14
22	55-60m					7	1		7	8
23	5-10m					3	1	1	3	4
29	0-5m					9	1		9	10
Total		2	2	8	6	47	22	3	65	87
East and North slopes										
34	25-30m			1		2	1		3	4
34	30-35m					1	2		1	3
34	35-40m	1		1			2	1	2	4
37	15-20m				1	3	2		4	6
37	20-25m						1		0	1
37	25-30m					2	2		2	4
38	10-15m	1				5	1		6	7
38	15-20m					5	4		5	9
40	10-15m	1	2			6	1		9	10
41	0-5m					2	2		2	4
41	5-10m					4	2		4	6
42	25-30m					3	3		3	6
43	10-15m					3	4		3	7
43	15-20m			1		4	4		5	9
Total		3	2	3	1	40	31	1	49	80
Overall Total		5	4	11	7	87	53	4	114	167

1982 Population estimate:

Number of sample sections:	Puffin Rock:	34 (2,403 m^2 - 10.3% of colony)
	Main island:	12 (1,374 m^2 - 2.9% of colony)
Average density:	Puffin Rock:	6,092 ± 551 burrows/ha
	Main island:	3,646 ± 446 burrows/ha
Colony area:	Puffin Rock:	2.3 ha
	Main island:	4.8 ha
	Total:	7.1 ha
Total burrows:	Puffin Rock:	14,214 ± 1,286
	Main island:	17,556 ± 2,148
	Total:	31,770 ± 2,504
1982 Occupancy rate:	Puffin Rock:	74.7 ± 5.5% (65 of 87 known)
	Main island:	61.3 ± 5.2% (49 of 80 known)
	Overall:	68.2 ± 4.0%
1982 Nesting population:	Puffin Rock:	10,618 ± 1,237 pairs
	Main island:	10,762 ± 1,598 pairs
	Total:	21,380 ± 2,021 pairs

Hatching chronology: Records from occupancy plots (Table SC010-33) indicate that the majority of chicks hatched during the first two weeks of July (Table SC010-34).

Table SC010-34. Numbers of Tufted Puffin eggs and chicks found along transects, by date, on Triangle Island in 1982.

	July														
	11	12	13	14	17	18	19	20	21	24	26	27	28	30	31	Total
Eggs	8	1	6			1	4	1	2		2				1	26
Chicks	6	6	15	1	15	14	9	13	3	1	6	10	6	9	7	121
Total	14	7	21	1	15	15	13	14	5	1	8	10	6	9	8	147

	11-14 July	17-21 July	24-31 July
Eggs	15 - 36.6%	8 - 12.9%	3 - 7.1%
Chicks	26 - 63.4%	54 - 87.1%	39 - 92.9%
Total	41	62	42

Reliability of the toothpick method of determining occupancy. Results from three experimental plots set up on Puffin Rock to test the reliability of placing toothpicks at burrow entrances to determine occupancy showed that the toothpick method was not an accurate

indicator of burrow occupancy (Table SC010-35). The closest correspondence to the correct occupancy rate occurred after one night. If burrows were checked on the same day as they were placed, the indicated rate was lower than the actual rate, and if checked after more than one night, the rate was higher and became progressively more so as more days elapsed.

Table SC010-35. Observations on experimental plots to determine accuracy of the toothpick method of determining burrow occupancy of Tufted Puffins.

Plot on Tran. 3-P

Contents	Actual occupancy	Number of burrows with toothpicks knocked down				
	12 July 1508h	12 July 1915h	13 July 1045h	13 July 1800h	17 July 1300h	18 July 1900h
Adult and egg	2	2	2	2	2	2
Egg	2	1	2	2	2	2
Chick	2	0	2	2	2	2
Empty	6	0	2	2	5	5
% occupied	50%	25%	67%	67%	92%	92%

Plot on Tran. 16-P at 15-20m

Contents	Actual occupancy	Number of burrows with toothpicks knocked down		
	17 July 1745h	18 July 1215h	19 July 1140h	10 July 1545h
Chick	15	13	14	15
Empty	2	2	2	2
% occupied	88%	88%	94%	100%

Plot on Tran. 22-P 10-15m

Contents	Actual occupancy	Number of burrows with toothpicks knocked down		
	18 July 1815h	19 July 1210h	10 July 1540h	11 July 1700h
Egg	1	1	1	1
Adult	1	0	1	1
Chick	7	6	7	7
Empty	5	1	2	3
% occupied	64%	57%	79%	86%

Toothpicks were knocked down in empty burrows as well as in active ones. In the plot on transect 16-P, the toothpick method gave the correct percentage after one night, but not in the correct burrows - two burrows that were empty had toothpicks flattened and two burrows with chicks had their toothpicks still standing. After several days almost all toothpicks were knocked over. The most marked difference in results occurred when the occupancy rate was low. In the plot on transect 3-P, the actual occupancy rate was 50% whereas after five days the toothpicks indicated an occupancy rate of 92%.

1984: Many puffins appeared to be unsuccessful in 1984. Of 32 burrows examined on Puffin Rock, only eight (25%) were occupied. Hatching in those few occupied burrows was later than in 1982. Only 18% of occupied burrows held chicks on 22-25 July compared to 87% with chicks on a similar date in 1982 (17-21 July). Few birds flying to and from burrows were carrying fish at that time. Groups of puffins were rarely seen sitting out on slopes, suggesting that more time was required for foraging.

1985: Burrows that had been investigated for occupancy in 1984 were rechecked on 21 July 1985. Of 21 burrows with known contents, 19 were occupied, indicating an occupancy rate of 90%. There were nine chicks and 10 eggs in those occupied burrows, suggesting a hatching chronology later than 1982 and earlier than 1984.

1989 and comparison with 1982: We detected no change in distribution of nesting puffins between 1982 and 1989, and data from both years were used to map colony areas (Fig. SC010-4). As in 1982, most burrows occurred in Tufted Hairgrass (Table SC010-36). Burrow densities on Puffin Rock and on the main island in 1989 were significantly different ($p < 0.005$). Lengths of a sample of 101 burrows ranged from 0.2 to 3.0 m and averaged 0.8 ± 0.4 m.

Results of surveys in 1989 indicated that burrow density was lower than in 1982. Differences between years on Puffin Rock were not quite significant (Kruskal-Wallis test: $p = 0.052$), but were significant on the main island ($p < 0.05$).

Table SC010-36. Habitat locations of Tufted Puffin burrow entrances on Triangle Island in 1989.

Burrow locations	Number of burrows	Percent
Grass tussock	147	91.9
Into bank	5	3.0
Open ground	4	2.5
Shrubs-salmonberry	2	1.3
Rock	1	0.6
Fern	1	0.6
Total	160	

Though density estimates in 1982 and 1989 were significantly different, we believe that those differences were an artifact of sampling methodology. Survey design focused on puffins in 1982, and transects were more frequent throughout colony areas than in 1989. On the main island in 1982, transects were placed within obvious puffin colony, whereas in 1989, transect spacing was uniform around the island, and puffin colony was sampled incidentally. Sampling effort on Puffin Rock was 10.3% of colony area in 1982 compared to 0.8% in 1989. On the rest of the island, 2.9% of colony area was sampled in 1982 compared to 0.7% in 1989. Because the 1982 survey was concerned only with puffins and the sampling intensity was much higher than in 1989, we concluded that estimates of burrow density in 1982 are more reliable. We prefer to use those densities in the calculations of breeding populations in 1989.

Table SC010-37. Occupancy of Tufted Puffin burrows along transects on Triangle Island in 1989.

Date	Location		Empty	Adult + egg	Cold egg	Adult	Chick	Total occupied	Total known
	Tran	Plot							
20/06	P-1	1		1		1		2	2
20/06	P-1	2		1		2		3	3
20/06	P-1	3		1		1		2	2
20/06	P-1	5		1		1		2	2
20/07	P-1	6	1	6				6	7
20/06	P-1	7		3				3	3
20/06	P-3E	1		2				2	2
20/06	P-3E	2		4				4	4
20/06	P-3E	3	3	2				2	5
20/06	P-3E	4	1					0	1
20/06	P-3E	6		2				2	2
20/06	P-3E	7		2				2	2
20/06	P-3E	8	1	2				2	3
20/06	P-3W	1				1		1	1
20/06	P-3W	2	1					0	1
20/06	P-3W	4		3		1		4	4
20/06	P-3W	9		1				1	1
20/06	P-3W	11		1				1	1
20/06	P-3W	12		2		1		3	3
20/06	P-4	2		2				2	2
20/06	P-4	3		1				1	1
20/06	P-4	4	1	2				2	3
20/06	P-4	5	1					0	1
20/06	P-4	6		1				1	1
03/07	53	1	1	1				1	2
03/07	53	3	1					0	1
03/07	53	5	1			1		1	2
05/07	14	7		1				1	1
05/07	14	9				2		2	2
05/07	14	10	1	1				1	2
06/07	P-4	29	1	1	1			2	3
06/07	P-5	1		1	1			2	2
06/07	P-5	2				1	1	2	2
06/07	P-5	5		1				1	1
06/07	P-5	7			1			1	1
06/07	P-6	3	1				1	1	2
06/07	P-7	4		1				1	1
06/07	P-8	3		1				1	1
07/07	72	1		2		1		3	3
07/07	72	3		2				2	2
07/07	72	4	1	1				1	2
07/07	72	5				1		1	1
07/07	72	8				1		1	1
11/07	T-42	1		1		1		2	2
11/07	68	32			1			1	1
03/08	75	1					1	1	1
03/08	75	2	1				1	1	2
03/08	75	3					1	1	1
03/08	75	4					1	1	1
03/08	75	5		1				1	1
03/08	76	1					2	2	2
03/08	76	2					1	1	1
03/08	76	4					1	1	1
03/08	76	5				1	1	2	2
Total			17	55	4	17	11	87	104

Data from permanent monitoring plots on Puffin Rock provide support for the conclusion that numbers of puffin burrows have not declined. Four 10x10 m plots were established in 1984 and resurveyed in 1989. The area of those plots was over twice the area sampled along transects in 1989. Total burrow counts in the four plots suggest a slight increase between 1984 and 1989 (Table SC010-39).

Estimates of burrow occupancy rates on Puffin Rock and the main island were similar in 1989 (Table SC010-37), unlike those in 1982. Estimated rates were higher in 1989 than 1982 on both Puffin Rock and the rest of the island, though only rates on the main island were significantly different (Puffin Rock: $z = 1.424$, $p = 0.078$; Main island: $z = 2.657$, $p < 0.005$).

1989 Population estimate:

Number of sample plots:	Puffin Rock:	46 (184 m^2 - 0.8% of colony)
	Main island:	89 (356 m^2 - 0.7% of colony)
Average density:	Puffin Rock:	4,347 ± 583 burrows/ha
	Main island:	2,275 ± 272 burrows/ha
Colony area:	Puffin Rock:	2.3 ha
	Main island:	4.8 ha
	Total:	7.1 ha
Total burrows:	Puffin Rock:	10,143 ± 1,360
	Main island:	10,954 ± 1,310
	Total:	21,097 ± 1,888
1989 Occupancy rate:	Puffin Rock:	84.3 ± 3.9% (59 of 70 known)
	Main island:	82.4 ± 6.0% (28 of 34 known)
	Overall:	83.7 ± 3.7%
1989 Nesting population:	Puffin Rock:	8,551 ± 1,212 pairs
	Main island:	9,026 ± 1,261 pairs
	Total:	17,577 ± 1,749 pairs
Using 1982 burrow density:	Puffin Rock:	11,982 ± 1,217 pairs
	Main island:	14,466 ± 2,056 pairs
	Total:	26,448 ± 2,389 pairs

As noted above, we prefer to use burrow density estimates from 1982 for calculations of 1989 nesting populations. The resultant 24% increase in estimated population between 1982 and 1989 was due to higher occupancy rates in 1989.

Hatching chronology: The first chick was found on 6 July (Table SC010-37). Surveys were interrupted in the middle of July when most chicks probably hatched. Except for one adult still incubating, all chicks had hatched when we resumed surveys at the beginning of August.

Comparison with 1975 survey: Nesting populations in 1975 were estimated to be 25,000 pairs (Vermeer 1979). Original survey data were not available for statistical comparison with 1982 or 1989 results, but colony area (2.6 ha) and average burrow density (6,667 burrows/ha) on Puffin Rock, where plots were surveyed in 1975 (Vermeer and Summers unpubl.), were similar to those determined in 1982. Estimated colony area on the east side of the island in 1975 (0.9 ha) was less than that mapped in 1982 and 1989, but exploration of that area in

1975 was limited. Occupancy rate determined by placing toothpicks in burrow entrances in 1975 (95%) was higher than in 1982 and 1989. That method was considered unreliable at a later date (Vermeer pers. comm.). Higher occupancy rate accounted for the higher population estimate in 1975 than 1982, offsetting the smaller area estimate.

Predation and Mortality:

Eagles and falcons preyed on most nesting species (see below), but very few prey remains were encountered in surveyed quadrats, and we did not attempt to quantify predation levels. Ravens were seen taking cormorant eggs, crows captured Rhinoceros Auklet chicks from burrows, and Glaucous-winged Gulls were observed pirating murre eggs, eating Pelagic Cormorant and Cassin's Auklet chicks, and kleptoparasitizing puffins flying in with fish.

We kept records of the number of carcasses found along beaches in 1989 when we were searching for evidence of oil-related mortality. Over the study period we found a total of 63 Cassin's Auklet, seven Rhinoceros Auklet and one Tufted Puffin carcass. Of the Cassin's Auklet carcasses: 34 were recently dead breeding adults with no sign of external wounds; one was a recently dead, emaciated chick; 25 were old and partially decomposed; and three were depredated or scavenged. All the old carcasses and 20 of the fresh ones were found in the first three days of surveys. The rest were found through June and July. One recently dead adult was autopsied by C. Haist on 20 June. It was a female with a partially refeathered brood patch and heathly layers of subcutaneous fat and muscle tissue. It had a major contusion on the top of its head and was bleeding internally.

All Rhinoceros Auklet carcasses were recently dead adults in breeding plumage. One, that had been hit by a falcon the previous evening, was autopsied by C. Haist. It was a male weighing 550 g with healthy layers of subcutaneous fat and muscle tissue. There were puncture wounds through the chest and it had died from internal haemorrhaging. Other Rhinoceros Auklets had no sign of external injuries. The puffin had been preyed upon, probably by falcons.

Most birds found dead on beaches were in the vicinity of driftwood, and we suspected that many had died from impacting driftwood or shore rocks when flying off the slopes at high speeds. No oiled birds were seen.

Permanent Monitoring Plots:

Six Rhinoceros Auklet and four Tufted Puffin plots were established in 1984 and resurveyed in 1989 (Fig. SC010-4). Fifteen plots were established for Cassin's Auklets in 1989 (Table SC010-40; Fig. SC010-2). All plots were 10x10 m.

There was considerable variation in the numbers of burrows counted in Rhinoceros Auklet plots between 1984 and 1989 (Table SC010-38). No trend was apparent, though overall numbers of burrows and burrow starts were greater in 1989 than 1984. Plots in which burrow numbers declined were noted to have rocky, easily eroded soil. Increases occurred where soil was more stable.

Species identification was a problem in Rhinoceros Auklet plots. Experience gained during the more extensive survey in 1989 made us less willing to identify burrows as Cassin's Auklet or Rhinoceros Auklet when size was the only clue. More burrows were called unknown in 1989 than in 1984.

Less variability occurred in Tufted Puffin plots between 1984 and 1989. Three of four plots had similar numbers of burrows and one had a greater number in 1989 than 1984 (Table SC010-39).

Table SC010-38. Numbers of burrows in Rhinoceros Auklet permanent monitoring plots on Triangle Island in 1984 and 1989.

Plot	RHAU burrows	RHAU starts	CAAU burrows	CAAU starts	Unknown burrows	Unknown starts	Total burrows	Total starts
1984:								
1	27	2	11	3	7	1	45	6
2	55	9	3	0	0	0	58	9
3	120	6	2	0	0	0	122	6
4	83	25	15	0	0	0	98	25
5	128	15	19	0	0	0	147	15
6	123	0	23	0	0	28	146	28
Total	536	17	73	3	7	69	616	89
1989:								
1	55	10	39	11	10	8	104	29
2	98	15	17	12	15	11	130	38
3	73	9	4	2	2	2	79	13
4	53	12	20	4	16	21	89	37
5	81	12	6	1	21	12	108	25
6	75	11	64	9	19	15	158	35
Total	435	69	150	39	83	69	668	177

Table SC010-39. Numbers of burrows in Tufted Puffin permanent monitoring plots on Triangle Island in 1984 and 1989.

Plot	TUPU burrows	TUPU starts	CAAU burrows	CAAU starts	Storm-petrel burrows
1984:					
1	98	2	21	0	
2	69	0	6	0	
3	16	0	393	0	
4	64	0	49	0	
Total	247	2	469	0	
1989:					
1	100	7	40	5	
2	97	11	9	3	
3	12	0	440	9	
4	67	0	72	15	1
Total	276	18	561	32	1

Cassin's Auklet permanent plots contained only Cassin's Auklet burrows except for plots 14 and 15. Plot 14 was placed on the upper edge of Rhinoceros Auklet colony and contained eight Rhinoceros Auklet burrows plus three starts. Plot 15 contained one Tufted Puffin burrow.

Table SC010-40. Numbers of Cassin's Auklet burrows in Cassin's Auklet permanent monitoring plots on Triangle Island in 1989.

	Plot														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Burrows	86	187	257	305	139	181	126	171	247	237	211	379	122	71	344
Starts	16	14	51	27	32	52	23	32	16	27	21	22	7	12	17

Associated species:

Northern Fulmar *Fulmaris glacialis* - Mock courtship behavior of eight fulmars (dark phase) was observed on 10 July 1982 from 1800 to 1840 h around the cliffs on the west side of Puffin Rock. Three to five birds sat in Pelagic Cormorant nests while others flew around the cliffs, soaring up to nests, almost touching sitting birds, and then continuing around. Individual birds flew up to different sitting birds, sometimes one after the other in sequence around the cliffs. Pairs sat in nests for brief periods, engaged in courtship/feeding behavior, opening their bills and twining necks. At 1835 h one fulmar usurped a cormorant nest with two eggs. The fulmar sat on the eggs and then above the eggs for a few minutes, before flying off. All eggs had disappeared from the nest the following day. This kind of behavior was not observed again, and only one or two fulmars were seen on later dates.

Two dark birds were seen soaring along the west side of Puffin Rock on 6 July 1984. One dark and one with a white head were sighted on 19 July 1985. In 1989, there were two dark-phase and two light-phase birds soaring around the west side of Puffin Rock on 20 June.

Bald Eagles *Haliaeetus leucocephalus* - Our records indicate an increase from one nesting pair in 1982 to three pairs in 1989. Previous accounts suggest that numbers of nesting pairs fluctuates. Carl *et al.* (1951) found two old nests, but no evidence of breeding during their visit in 1949. Vermeer *et al.* (1976) confirmed breeding by two pairs, and observed two other attended nests in 1975. In 1982, we monitored one nest on the southwest corner of the main island, adjacent to Puffin Rock. The nest was on the ground on the top of the projecting rock ridge. One young fledged from that nest on 19 July.

In 1984, One young again fledged on 19 July from the same nest monitored in 1982. Another pair defended a territory on the southeast point at the top of the ridge, but no nest was located. An unattended, dilapidated nest was located on Sentinel Pinnacle.

A pair was definitely nesting on the southeast ridge in 1985. Two large young attended by one adult were standing in that nest, and one full grown young was standing in the nest at the southwest corner when we arrived 9 July. The young at the southwest nest fledged on 17 July. Two young were still in the southeast nest when we left on 25 July.

We located three nesting pairs in 1989: two at the same locations recorded in 1985, and one in the northeast bay (Fig. SC010-4). There was also an unused nest in the northeast bay

which probably belonged to the same pair. We suspect this was a new nesting territory established sometime between 1985 and 1989. Though little time was spent in the northeast bay in previous years, we always explored it at least once during a season, and had never observed adult eagles there prior to 1989. In 1989, adults were territorial and always conspicuous. There was one downy young and one egg in the northeast nest on 6 June. On 9 June, an adult was in the nest with the chick, plucking a Cassin's Auklet. The egg appeared to have been pushed aside.

Two half-grown young were visible in the southeast nest on 18 June. One was beginning to lift off slightly on 27 July, and fledged on 30 July. The fledged chick returned to the nest periodically and sat with the other chick. The second chick began exercising wings on 9 August, and fledged on 13 August. We could not see young in the southwest nest until 4 July, when one large, fully feathered chick was exercising its wings at the edge of the nest. That young fledged 28 July, though it was still being fed in the nest on 29 and 31 July.

Groups of immature, subadult and nonbreeding adults were present each year. They were commonly encountered in the northwest bay, or seen soaring over the top of the island. Largest numbers occurred in June and July in 1989. The maximum sighted each season were: four adults and seven immatures on 10 July 1982; five adults, seven immatures and two unaged on 12 July 1984; five immatures and two adults 17 July 1985; and 15 immatures and subadults on 8 June 1989. Fourteen immatures were present in early July 1989, but by August, only three or four were seen. Similar maximum numbers were reported by Carl *et al* (1951) and Vermeer *et al.* (1976).

During our explorations of interior slopes in 1989, we encountered small openings in the dense vegetation that had been worn bare by eagles. Most were located on the edges of major gullies amongst tall shrubbery. They showed signs of intensive use, strewn with feathers, pellets and droppings. As many as six immatures and subadults were seen clustered at a site.

Observed prey of eagles included Glaucous-winged Gull chicks, Common Murres, Cassin's Auklets, Rhinoceros Auklets, Tufted Puffins and rabbits. Scavenged sea-lion pups were regularly encountered.

Peregrine Falcon *Falco peregrinus* - Two eyries were suspected in 1982 and 1984 on the north and south corners of the east side. On 14 July 1982, two adults with one fledged young were sighted at both those locations. Two adults with one fledged young were flying above the southeast ridge on 18 July 1984.

In 1985, pairs were seen over the southeast ridge and in the northeast bay. Three birds were sighted over the southwest ridge, and single birds were sighted on the west side of Puffin Rock, at Land's End and at Carrot Point.

During the more exhaustive explorations in 1989, we located seven possible eyrie sites: north and south corners of the east side; east and north corners of the northeast bay; north end of the west bay; east side of the southwest ridge; and on the east side of Puffin Rock. Pairs were sighted at five of those sites. Single birds were seen at the east corner of the northeast bay and in the west bay. The eyrie on Puffin Rock contained two full-sized young on 20 June, and the pair at the south end of the east side was seen with one fledged young on 23 and 24 June.

Cassin's Auklets were the primary prey, but falcons were observed hunting puffins and Rhinoceros Auklets. A plucking site located in 1982 on a small rocky ridge on the west side of the southeast point was littered with Cassin's Auklet feathers. On 6 June 1989, we found 11 Cassin's Auklet carcasses plus two separate wings below the eyrie at the north end of the east side. On 7 July, we were entertained by one to three juveniles harassing Tufted Puffins around the west side of the northeast bay. A freshly eaten puffin carcass was found there the following day. In 1985, we saw a bird on Puffin Rock feeding on an adult Tufted Puffin.

Unusual hunting behavior was observed amongst circling flocks of Rhinoceros Auklets in the south bay on 21 June 1989. At 2200 h, as it was getting quite dark, a female or immature bird dove and hit a circling auklet in typical falcon fashion. It dropped the bird and did not recover it. Twenty minutes later, the falcon materialized out of the fog matching the pace of the circling flock of auklets. It then simply latched on to one bird as they were flying together. The novel tactic was not successful as the auklet struggled and managed to free itself. We found one dead auklet on the beach in the morning with puncture wounds through the chest. It was probably the bird first hit in a stoop.

Evidence of predation or scavenging on falcons was observed in 1989: feathers and ripped pieces of skin were found in the south bay on 2 July; and bloody feathers from a partially grown falcon chick were encountered in the northwest bay on 9 July.

Marbled Murrelet *Brachyramphus marmoratus* - Single birds in winter plumage were sighted diving in the south bay on 9 July 1985 and 1 August 1989. Two were seen on 6 August 1989.

Horned Puffins *Fratercula corniculata* - Nesting by two or three pairs of Horned Puffins was suspected but not confirmed. A maximum of six were seen on the west side of Puffin rock on 16 July 1982. One adult was sitting on the north slope of the main island on 31 July. Only one was seen in 1984 on 12 and 14 July. Two were sighted on the west side of Puffin Rock on 16 July 1985. In 1989, we saw a maximum of four flying around the east side of Puffin Rock on 4 June. Two or three were regularly sighted around Puffin Rock throughout the study period. Single birds were on the water off the north side on 12 and 13 August.

Northwestern Crow *Corvus caurinus* - Our records indicate an increase in numbers and a change in distribution of crows between 1982 and 1989. Maximum numbers sighted were: eight in 1982; 36 on 21 July 1984; 26 on 21 July 1985; and 41 on 2 July 1989. Largest numbers occurred after chicks had fledged, and populations may have fluctuated in relation to breeding success. Historical records suggest that crows colonized the island between 1949 and 1974. No crows were observed in 1949 (Carl *et al.* 1951). Nesting and a maximum of 20 birds were reported in 1974 and 1975 (Vermeer *et al.* 1976).

Crows were observed only on the south side of the island as far as Puffin Rock in 1982, 1984 and 1985. None were encountered around the rest of the island. In 1989, crows were concentrated in the south bay, and we suspected that was the only area they were nesting, but small numbers were sighted flying around most sections of the island. One fledged young was being fed on 10 July 1982. There were young of the year flying about when we arrived on 5 July 1984, and we suspected four or five families nesting.

Crows foraged in tidal areas and on Rhinoceros Auklet nesting slopes, looking for dropped fish and even taking young chicks on occassion (Butler *et al.* 1985). The concentration of crows in the south bay, especially in July, may be related to opportunistic supply of dropped fish during the Rhinoceros Auklet nestling period.

In 1984, the entire flock gathered on the beach, clustered in what appeared to be a "requiem" for a dying crow. Part of the flock kept vigilance over the bird until it died.

Common Raven *Corvus corax* - One pair of ravens were present every year. A maximum of 4 were seen in 1982. They were frequently seen foraging the Rhinoceros Auklet slopes in the mornings. Only 2 were present in 1984. They were using the old lighthouse base as a roost site. Three fledged young with one adult were sighted around the Impasse on 17 July 1985. They periodically foraged in the south bay during the rest of July. In 1989, we located what we assumed was a raven nest in a hole in the cliff south of the Impasse. Though there was a pair in the area, they were not territorial, and we saw no indication of nesting. We scared what we suspected was the same pair out of a crabapple thicket high on the slope at the west end of the south bay on 15 June. Three were flying over the south bay on 16 August.

Ravens were observed flying off with cormorant eggs from nest sites on the Impasse on 17 July 1985.

Other birds and mammals sighted:

Red-necked Grebe *Podiceps grisegena* - One first-winter bird in south bay on 9 June 1989.

Sooty Shearwater *Puffinus griseus* - No shearwaters were recorded in 1982. Six were sighted on 10 July 1984. Constant streams of shearwaters were flying east to west past Triangle Island on 10 and 11 July 1985. Counts of birds flying past per minute were made: 44 at 0924 h; 10 at 1835 h; 20 at 2126 h on 10 July; 78 at 0944 h; 44 at 1403 h; 38 at 1710 h on 11 July. Those counts suggest a movement of 50-100,000 shearwaters over a two day period. Some were still flying past in the morning of 12 July, but none were sighted in the afternoon or evening. Smaller movements occurred in the morning of 18 July (29 per minute at 0930 h), 20 July (10 per minute at 0948 h). There were 110 feeding in a fish boil off the south bay at 0930 h on 20 July.

No large movements were observed past Triangle Island in 1989. On the water off the north side of the island, we recorded eight on 4 August, 60 on 13 August and 50 on 15 August.

Great Blue Heron *Ardea herodius* - One bird with a white stripe on the top of its head was present between 5 July and 16 August 1989. During that period, we encountered what we assumed was the same bird in various locations around the island. There were two on the east side of Puffin Rock on 8 August.

Green-winged Teal *Anas crecca* - 14 at the southwest corner on 14 August 1989.

Scaup sp. *Aythya* sp. - One in the south bay on 30 July 1982.

Harlequin Duck *Histrionicus histrionicus* - A small flock of male Harlequin Ducks frequented the south bay in all years. A group of up to 15 were present throughout our stay in 1982. Five males just beginning to molt on 10 July, were in eclipse plumage by 21 July. A maximum of eight males were present in 1984. Their molt into eclipse plumage was almost complete by 23 July.

In 1985, four to eight males in various stages of molt were present throughout the study period. Birds in all stages, from full nuptial to eclipse were seen on 10 July. All birds were in eclipse plumage by 17 July.

We saw one male at the northeast corner on 7 June 1989. Five males were in the south bay on 9 and 10 June, and one bird in female plumage was sighted on 11 June. The number of males increased to eight by 6 July. They were molting between 23 June and 30 July. One male still in nuptial plumage arrived on 6 July. By 9 July, three were still molting, but the rest were in complete eclipse. All were in eclipse by 30 July. A maximum of 13 birds were present on 9 August.

Red-breasted Merganser *Mergus serrator* - Two females or immatures on 11 June 1989.

Northern Harrier *Circus cyaneus* - One seen on 31 July 1982.

Red-tailed Hawk *Buteo jamaicensis* - One immature observed 11 to 16 July, with a second seen on 14 July 1984.

Greater Yellowlegs *Tringa melanoleuca* - One on 17 July 1985; one on 3 July and two on 12 July and 14 August 1989.

Wandering Tattler *Heteroscelus incanus* - One or two seen frequently in 1982 and 1984. One on 21 July 1985. Two on 12 August and five on 19 August 1989.

Spotted Sandpiper *Actitis macularia* - One on 23 July 1984; one on 10 July and 8 August, and two on 12 August 1989.

Whimbrel *Numenius phaeopus* - One seen 9 July 1982 and 13 July 1984.

Ruddy Turnstone *Arenaria interpres* - One on Castle Rock on 6 August 1989.

Black Turnstone *A. melanocephala* - One on 9 July and two on 19 July 1982; four on 16 July 1984; 16 on Castle Rock on 6 August 1989.

Western Sandpiper *Calaidris mauri* - Small numbers were seen most years. We saw four on 13 July 1982. In 1985, there were seven in summer plumage on the south beach on 9 July, two in summer plumage plus three beginning to molt on 11 July, and one in mostly winter plumage on 20 July. They were first seen in 1989 on 28 June when there were two on the south beach. There were 10 on 30 June, 12 in summer plumage on 2 July, one on 11 July, and 14 on 14 August.

Least Sandpiper *C. minutilla* - Four on 13 July and one on 20 July 1982; one on 11 July and three on 15 and 16 August 1989.

Ring-billed Gull *Larus delawarensis* - One first-year on 12 July 1984.

California Gull *L. californicus* - We recorded two adult and two immatures on 10 July 1982. There was an influx of juveniles at the end of July 1989 - 33 were roosting in the south bay and two were circling amongst Glaucous-winged Gulls on Puffin Rock on 31 July. We sighted 60 juveniles off the north side on 12 August.

Herring Gull *L. argentatus* - In 1984, we saw one adult, one first-year and one second-year bird on 20 July, one adult and one third-year bird on 22 July, and one adult and two subadults on 28 July.

Western Gull *L. occidentalis* - One second-year bird on 9 July 1984.

Glaucous Gull *L. hyperboreus* - One second-year bird on 16, 18 and 21 July 1985.

Caspian Tern *Sterna caspia* - Four on 12 July 1984.

Snowy Owl *Nyctea scandiaca* - We found an old carcass of an immature bird washed up on the south beach when we arrived on 9 July 1985.

Short-eared Owl *Asio flammeus* - Two flushed out of grass on the southeast ridge above Calamity Cove on 19 July 1984.

Black-chinned Hummingbird *Archilochus alexandri* - One male on 9 July 1984.

Anna's Hummingbird *Calypte anna* - One female on 12 and 13 July 1982, and one or two present 5 to 9 July 1984.

Rufous Hummingbird *Selasphorus rufus* - One female on 9, 10 and 12 July, plus one male on 12 July 1982; one male and one female or immature on 15 July 1984; and one female on 18 June 1989.

Belted Kingfisher *Ceryle alcyon* - On 31 July 1982, we saw a female being chased by three Peregrine Falcons. One bird was foraging in the south bay on 15 August 1989.

Western Flycatcher *Empidonax difficilis* - One at top of west slopes on 28 June 1989.

Tree Swallow *Tachycineta bicolor* - Three over Saxifrage Ridge on 11 July 1989.

Barn Swallow *Hirundo rustica* - One on 16 July 1984.

Winter Wren *Troglodytes troglodytes* - Present and singing regularly in all years. A recently fledged young was observed on 18 July 1985. An adult was observed flying with nesting material into a nest in a tuft of grass on a small cliff face in the west bay on 19 June 1989.

Ruby-crowned Kinglet *Regulus calendula* - One on 24 July 1984.

Swainson's Thrush *Catharus ustulatus* - We heard birds singing on 9 July 1982 and on 5 and 13 July 1984. In 1989, there were sporadic birds heard singing on most days we were on the top of the island.

Cedar Waxwing *Bombycilla cedrorum* - Seven on 18 July 1984.

Orange-crowned Warbler *Vermivora celata* - Seen and heard singing regularly in all years. Frequently seen feeding young.

Common Yellowthroat *Geothlypis trichas* - A male and female were sighted around camp on 6 June 1989.

Fox Sparrow *Passerella iliaca* - Fox Sparrows were seen and heard regularly in most areas. One nest with three downy young was located in tall salmonberry in the south bay on 13 July 1984. Fledged young were seen on 19 July. Fox Sparrows displayed interesting foraging behavior on south slopes. They appeared to be using long strip territories that extended in narrow bands up slope. Birds were observed foraging 30 to 50 m up slope and then plumetting to presumed nest sites below. One nest with two eggs was found in salmonberry on 15 June 1989.

Song Sparrow *Melospiza melodia* - Song Sparrows were probably the most abundant passerine on Triangle Island. They were regularly seen and heard singing in all parts of the island. In 1984, one nest found in the grassy slopes above Calamity Cove contained three naked young on 19 July. Many fledged young were observed after 17 July. One fledged young begging from an adult was recorded 10 July, and a recently fledged young was sighted on 16 July 1985. Two nests were found on grassy slopes in the west bay on 10 June 1989: one with four eggs and one with two eggs and two newly hatched young. Nests were made of woven grass.

Brown-headed Cowbird *Molothrus ater* - One adult male on 29 July 1989.

Red Crossbill *Loxia curvirostra* - Sporadic flocks were sighted most years: 15 on 11 July, 20 on 12 July and 15 on 20 July 1982; maximum of 50 sighted on 14 July 1984; and 16 over the Saxifrage Ridge on 9 June, 20 over southeast ridge on 24 June and 15 along upper west side 4 July 1989.

Pine Siskin *Carduelis pinus* - Small flocks were observed periodically in 1984 and 1989: six on 15 July 1984; and three flying and calling over southeast point on 23 June and five seen on the upper west side on 4 July 1989.

Mammals

Whales - Three whales were spouting and breaching offshore on 12 July 1985. We suspected they were Humback Whales (*Megaptera novaeangliae*).

Harbour Seal *Phoca vitulina* - One or two were seen regularly in the south bay, and larger groups were present in other areas in all years. A maximum of 43, including eight pups, were counted off the north side on 9 July 1982. In 1984, groups of up to 35 were regularly present at the south end of the west bay ("Seal Corner"). Maximum numbers sighted in 1985 were 24 adults and seven pups on the north side on 17 July, 16 in the west bay on 11 July, and eight hauled out on the beach at Carrot Point on 20 July.

Larger numbers were counted in June in 1989: 83 in Seal Corner on 10 June; 23 plus nine new pups on the west side of the southeast point on 23 June; and 15 at Carrot Point on 24 June. In July, we recorded 29 plus one pup in Seal Corner and eight plus one pup in the northwest bay on 3 July, 11 plus one pup at the base of Puffin Rock on 6 July, and 42 plus one pup in the northeast bay on 11 July. Birthing of three pups occurred on the beach in Calamity Cove on 23 June.

Northern Sea Lion *Eumetopias jubatus* - No count was made in 1982, but adults were abundant and pups were seen on rocks off the north and west sides. On 12 July 1984, we counted 374 adults plus a number of pups hauled out on reefs off the north and west sides. Three dead pups were found on shore around Sentinel Pinnacle, one of which had been scavenged by eagles. In 1985, we counted 215 adults plus 18 pups on the north and west sides on 17 July. We found 3 old, dead pups on Orphan Spit and another on the north beach.

Between 6 and 8 June 1989, we counted 354 around the island: 104 at the southeast point; 102 with two pups on the northwest rock; seven females on Sentinel Pinnacle plus three abandoned pups on Orphan Spit; 120 on the North Pinnacles; and 16 bachelor bulls on the reefs off Carrot Point. The three pups observed on Orphan Spit were dead on 21 June. Higher numbers were recorded at the end of June and beginning of July: 229 adults plus 11 pups on the southeast point on 23 June; 69 off Carrot Point on 24 June; and 335 adults plus 27 pups on the North Pinnacles and 94 on the reefs west of Castle Rock on 11 July. There were 32 pups visible on the southeast reefs on 5 July.

Sea Otter *Enhydra lutris* - One male amongst tidal rocks at Carrot Point, named in his honour.

Deer Mouse *Peromyscus maniculatus triangularis* - Abundant around camp.

Townsend's Vole *Microtus townsendi cowani* - Seen on the slopes and around burrows, as well as around camp.

Rabbit - Rabbits were brought to Triangle Island by early lighthouse keepers. Small numbers were seen in all parts of the island.

SC-020 SARTINE ISLAND 103 I/15

Location: Southeast of Triangle Island. 50°49'10"N 128°54'20"W

Land status: Provincial Ecological Reserve.

Description: Sartine is a windswept, treeless island with steep, rocky sides. It is composed of a series of rounded, or flat-topped knolls, rising to a maximum elevation of 113 m, and joined by knife-edged saddles. Except for large boulders and a fringe of gravel at the base of some east slopes, there are no beaches or shelves, and it is impossible to walk the shoreline very far in any direction. The main island is 28 ha in size, 16 ha of which are vegetated. It is grassy, predominantly *Calamagrostis nutkaensis*, plus *Elymus mollis* on lower slopes and *Deschampsia caespitosa* on edges above rock faces. *Conioseleum pacificum* and *Montia* sp. are common on grassy slopes. Dense salmonberry, 1.0 -1.8 m high, covers the entire northern slope of the largest section of the island, but is sporadic in other areas. *Tellima grandiflora* is frequent under dense salmonberry. Outer rocks are bare pinnacles, with a cummulative area of 5.2 ha (Fig. SC020-1).

Sartine Island was designated an Ecological Reserve in 1971. An automatic weather station was established on the top of the main section of the island in 1984.

Date of visit: 9, 11, 13 July 1987 (transects or total counts for all species); 11 June 1989 (occupancy for Cassin's Auklets, counts of surface nesting species); and 29 July 1989 (counts of surface nesting species).

Colony access: Drop-off from boat.

Sensitivity: Like Triangle Island, Sartine Island supports high densities of breeding seabirds, which are highly vulnerable to human disturbance. Close approach or landing by helicopter during the breeding season disturbs nesting birds and can result in abandonment.

Observers: 1987: M. Lemon, M. Rodway, B. Carter, R. Chaundy. 1989: M. Rodway, K. Summers, B. Carter, D. Grinnell.

Census methods: **1987:** Seven line transects with 174 plots, 1x1 m, were surveyed on accessible slopes (Fig. SC020-2; Table SC020-1). During exploration, we were unable to reach the top of the large, flat-topped knoll towards the north end of the island. Habitat there was similar to adjacent areas (transect 6), and we extrapolated nesting distribution accordingly. For Tufted Puffins on that knoll, we defined colony as areas where adults were sitting out on slopes.

Table SC020-1. Bearings and total length of transects on Sartine Island in 1987.

Transect	Bearing (°)	Length (m)	Average slope (°)	Range of slopes (°)
1	225	130	30	0-80
2	225	86	43	35-50
3	225	236	25	10-50
4	225	256	22	5-55
5	253	86	40	10-65
6	60	15	20	15-39
7	265	115	28	0-52

Colony area on the top of the island was mapped and measured on an enlarged air photo, but available topographic or air photo maps were inadequate for mapping colony areas on side slopes. We took a series of detailed photographs around the island from the water, and used enlargements of those to map and measure colony areas on side slopes (Fig. SC020-2, B and C).

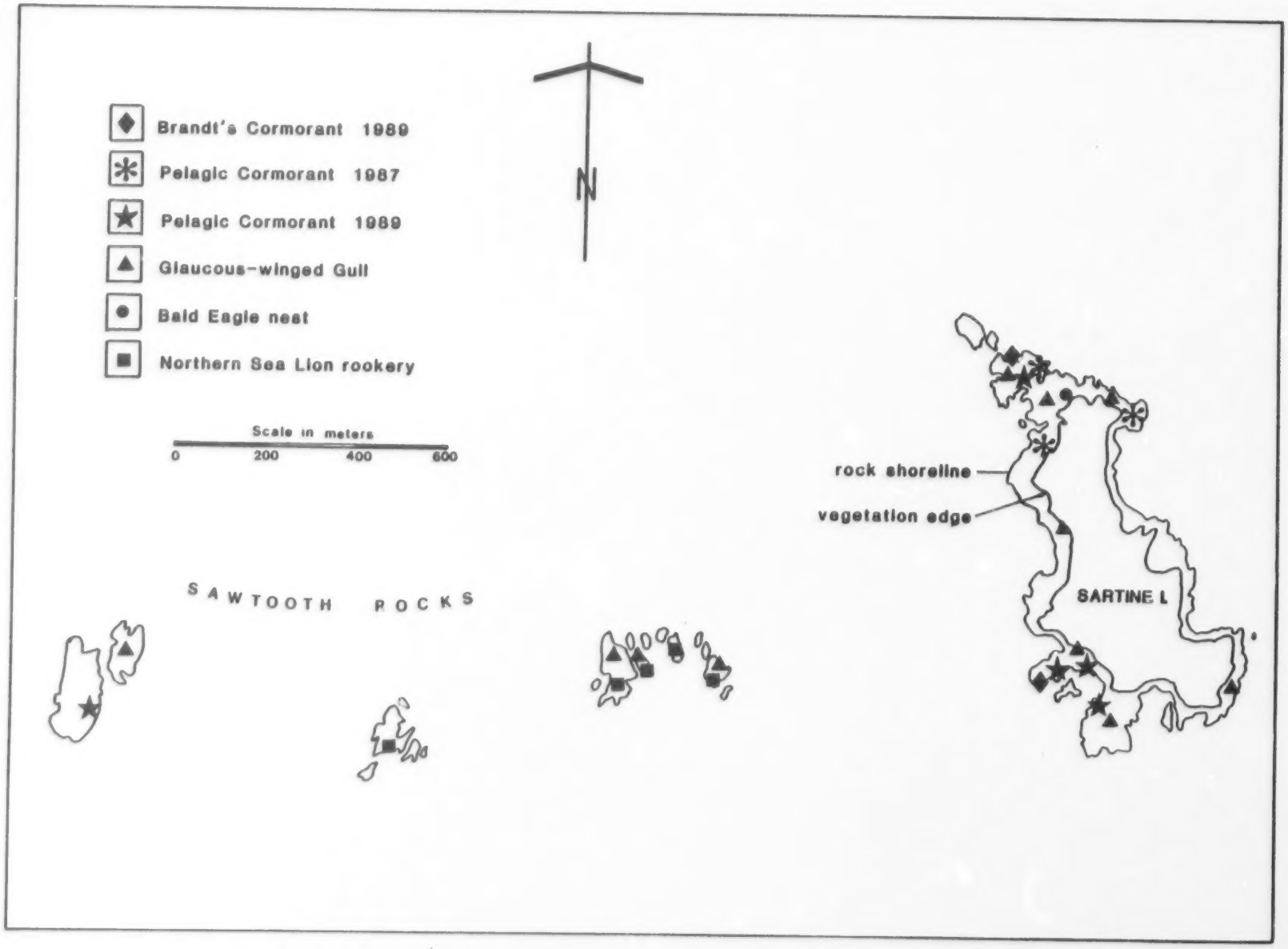

Figure SC020-1. Locations of surface nesting species on Sartine Island in 1987 and 1989.

Total counts were made of cormorant nests, gulls on territories and Pigeon Guillemots around the island.

1989: Occupancy for Cassin's Auklets was determined in four plots with 10 known burrows each. Plots were located in the vicinity of 1987 transects 2 and 3, and were spaced 30 m apart, beginning 15 m from the shore edge of the vegetation. Total counts were made of cormorant nests, gulls on territories and Pigeon Guillemots around the island.

Nesting species:

Brandt's Cormorant: Vermeer *et al.* (1976a) observed adults at nests in August 1975, but breeding was not confirmed at that time. We saw no Brandt's Cormorants in 1987, but on 29 July 1989, they were attending nests with large young. A total of 39 nests were counted: 31 on low rocks near the southwest corner of the main island, and eight on the north end (Fig. SC020-1). The contents of 23 nests on the west side were determined:
10 with one young; seven with two young; four with three young; one with four young; and one with five young. All nests were attended by at least one adult, four had two adults attending. No young were visible in nests on the north end. Three nests there had adults sitting in them, the rest had adults standing beside them.

Pelagic Cormorant: We counted 137 attended nests on 9 July 1987. All nests were located on pinnacles and bluffs at the north end of the island (Fig. SC020-1).

On 11 June 1989, we counted 168 nests with adults on rocks and cliffs at the southwest corner of the island. None were seen elsewhere. An additional 53 cormorants were roosting on the outer "Sawtooth Rock" (21) and at the southwest corner of the main island in the vicinity of nesting birds (32). A second count on 29 July tallied 164 nests, but only 49 had attending adults, the rest were abandoned. Most nests were still on rocks and cliffs at the southwest corner, in the same area Brandt's Cormorants were nesting. There were only 12 attended plus 10 abandoned nests at the north end of the island where nests were located in 1987. Six nests with adults sitting on them were located on the outer west of the Sawtooth Rocks. Five abandoned nests were seen at the southeast corner of the main island. Contents of 15 attended nests on the southwest rock were determined: two empty; five with one young; six with two young; and two with three young. Eighty-three roosting birds, many of which were immatures were counted on Sawtooth Rocks.

Black Oystercatcher: We suspected one pair nesting in 1987 and 1989. There was a pair on the east side on 9 and 13 July 1987, and one pair on the west rocks were very excited and territorial on 29 July 1989. We sighted a maximum of three in 1987 and 10 in 1989.

Glaucous-winged Gull: We counted 485 adults on territories on 9 July 1987 (Table SC020-2). We estimated the nesting population to be 240 pairs. Chicks were visible.

On 11 June 1989, there were a total of 777 adults on territories. An additional 122 adults roosting on low rocks were counted. We made a second count on 29 July and tallied 551 adults on territories. Large chicks were visible in all areas. Seventy adults were roosting on low rocks. Using the higher count made on 11 June, we estimated the nesting population in 1989 to be 390 pairs.

Table SC020-2. Numbers of Glaucous-winged Gulls counted on territories on Sartine Island in 1987 and 1989.

Location	Date 9 July 1987	11 June 1989	29 July 1989
Southwest rock	27	33	69
Southwest side	81	85	50
North end	74	100	68
Northwest pinnacles	53	50	44
East side	0	17	4
Sawtooth Rocks	250~	492	316
Total	485	777	551

~ numbers were estimated.

Common Murre: We observed no evidence of nesting in 1987 or 1989. We estimated 270 birds on the water off the east side of the island on 9 July and 440 off the west side on 11 July 1987, and saw a maximum of 113 north of Sawtooth Rocks on 29 July 1989. We never saw birds on cliffs or circling cliffs.

Pigeon Guillemot: A maximum of 176 birds were counted around the island at 1300 h on 11 July 1987. The contents of three nests were determined on 13 July: one with two downy chicks; one with adult sitting on eggs; and one with a freshly hatched eggshell.

We counted a maximum of 68 around the main island and 48 around Sawtooth Rocks, giving a total of 116, on 29 July 1989. Birds were seen flying in and out of crevices.

Cassin's Auklet: 1987: Cassin's Auklet burrows were abundant in most grassy areas, but were sparse in the middle of the southeast slope on the main section of the island, and in some pockets of *Elymus*. Burrows were sporadic under dense salmonberry (Fig. SC020-2: Table SC020-3).

Most occupied burrows held chicks at the time of the 1987 survey (Table SC020-4). Chicks had already fledged from 41% of occupied burrows checked between 9 and 13 July. Three burrows (8%) held adults still incubating eggs.

Mean length of a sample of 40 burrows was 0.7 ± 0.3 m. Lengths ranged from 0.4 to 1.5 m.

1987 Population estimate:

Number of sample plots:	174 (174 m^2 - 0.1% of colony)
Average density:	27,816 ± 1,503 burrows/ha
Colony area:	14.9 ha
Total burrows:	413,079 ± 22,316
1987 Occupancy rate:	91 ± 4% (39 of 43 known)
1987 Nesting population:	375,902 ± 26,597 pairs

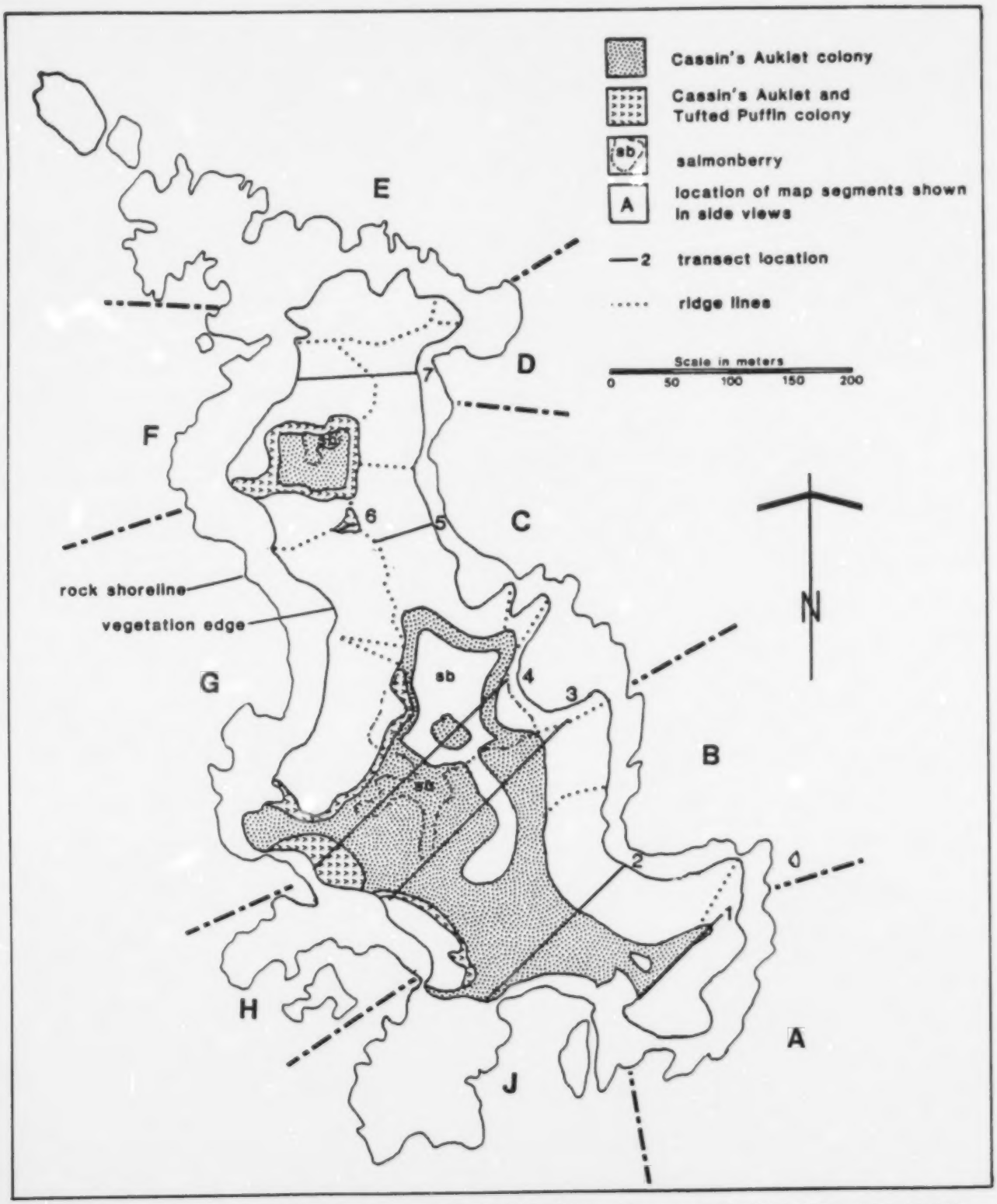

Figure SC020-2. Cassin's Auklet and Tufted Puffin colony on Sartine Island in 1987. A. Colony areas measured from aerial view.

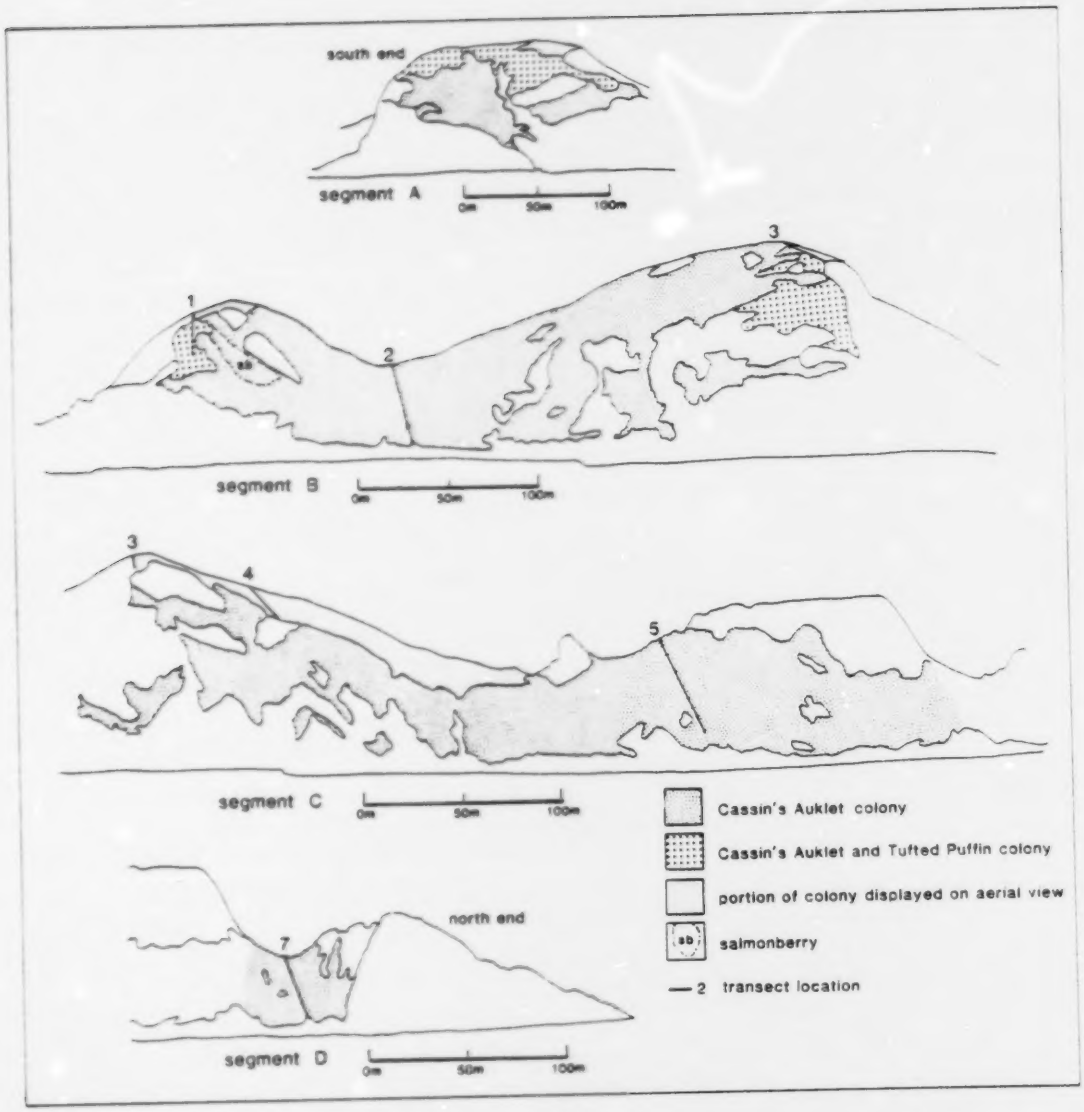

Figure 8C020-2. B. Colony areas on east slopes measured from side view.

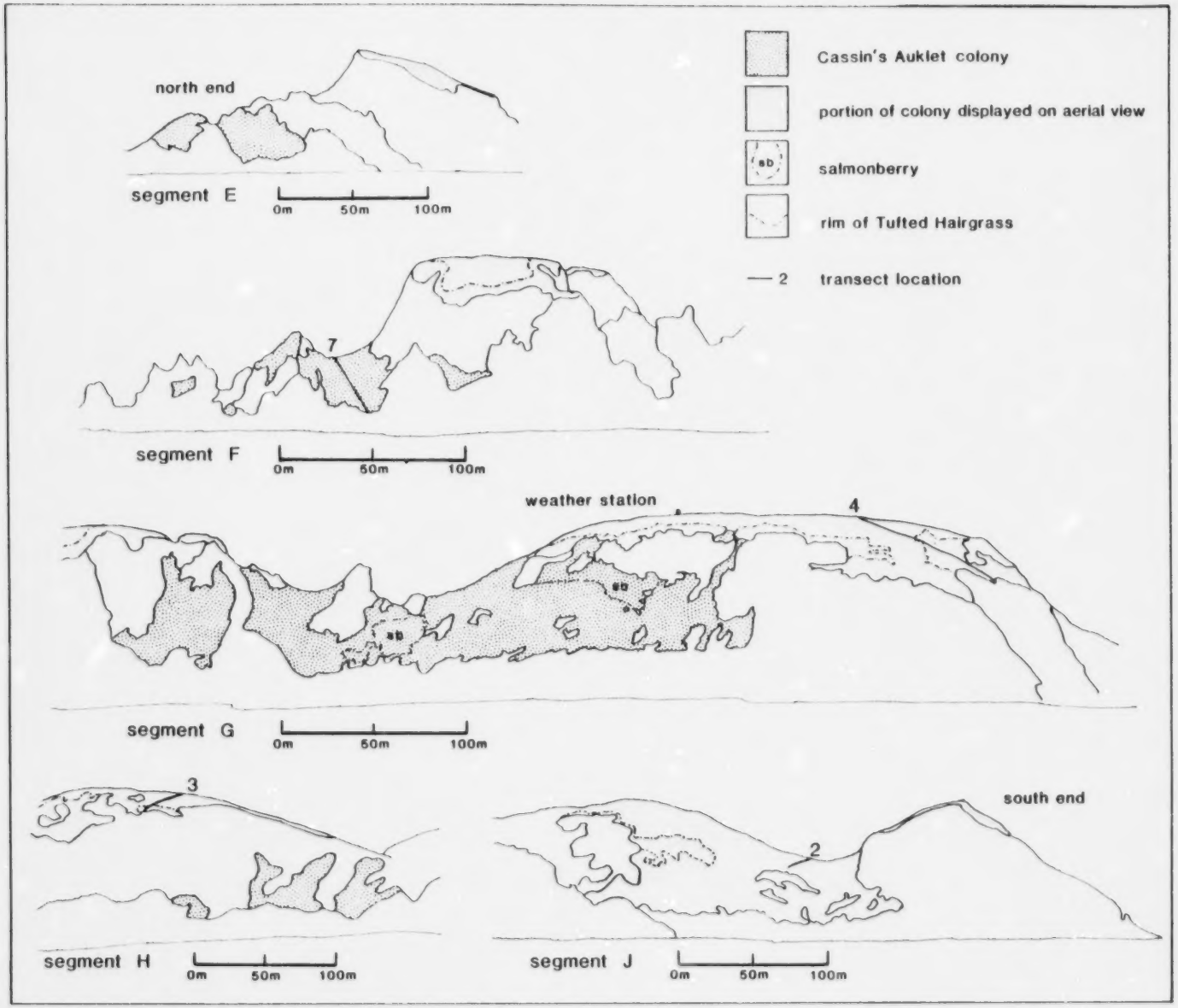

Figure SC020-2. C. Colony areas on west slopes measured from side view.

Table SC020-3. Number of Cassin's Auklet burrows in 1x1 m plots along transects on Sartine Island in July 1987. Plots considered outside the colony are indicated by a dash.

Plot	Transect						
	1	2	3	4	5	6	7
1	3	2	3	3	0	0	4
2	2	3	6	3	2	3	3
3	2	3	4	1	1	5	4
4	6	7	3	3	1	1	0
5	5	4	7	3	3		1
6	5	2	8	-	4		0
7	3	1	5	-	0		0
8	4	5	4	-	2		1
9	2	8	2	-	0		0
10	4	4	5	-	2		7
11	3	4	0	-	0		4
12	3	5	1	-	1		5
13	6	5	0	0	0		3
14	3	0	0	2	0		2
15	3	1	1	1	2		3
16	3	7	0	1	4		0
17	3	5	2	2	3		5
18	4		-	-	0		3
19	5		-	-			4
20	7		-	-			5
21	5		-	-			1
22	4		5	-			0
23	4		0	1			0
24	7		3	1			3
25	4		6	1			
26	2		0	0			
27	2		2	0			
28			2	1			
29			3	4			
30			1	3			
31			4	6			
32			3	3			
33			3	2			
34			4	1			
35			3	0			
36			2	4			
37			3	4			
38			2	2			
39			4	1			
40			1	0			
41			6	4			
42			3	5			
43			6	5			
44			3	2			
45			0	3			
46			4	0			
47			5	4			
48			2	3			
49				5			
50				3			
51				3			
52				1			

Table SC020-4. Occupancy of Cassin's Auklet burrows along transects on Sartine Island in July 1987. Locations marked with an asterisk were in the vicinity of the listed plot.

Occup. plot	Date	Tran	Plot	Empty	Adult + egg	Chick	Fledged chick	Unknown	Total occupied	Total known
1	09/07	1	4*				2	3	2	2
2	09/07	1	7*				1		1	1
3	09/07	1	13*			1			1	1
4	09/07	1	18*		1			2	1	1
5	09/07	1	19*				1		1	1
6	09/07	1	20*			4			4	4
7	09/07	1	24*			2		1	2	2
8	09/07	1	26*	1		2			2	3
9	09/07	2	2*			2	1	1	3	3
10	09/07	2	5*		1		3		4	4
11	09/07	2	9*					5	0	0
12	09/07	2	13*			1		2	1	1
13	09/07	3	12				1		1	1
14	09/07	3	15			1			1	1
15	09/07	3	17*			1	1	2	2	2
16	11/07	3	27			1			1	1
17	13/07	5	18*	1		1			1	2
18	13/07	7	1*	1			1	2	1	2
19	13/07	7	3*			1	1	1	2	2
20	13/07	7	7*			2	2		4	4
21	13/07	7	9*				2		2	2
22	13/07	7	18*					3	0	0
23	13/07	7	19*	1	1	1		2	2	3
24	13/07	7	22*					3	0	0
Totals				4	3	20	16	27	39	43

1989: Occupancy rate in the 40 burrows examined on 11 June 1989 was 95.0 ± 2.2%. It was similar to that determined in 1987. In the four plots of 10 known burrows each, there were 9, 9, 10 and 10 occupied burrows. Except for one adult incubating an egg, all occupied burrows contained chicks of various ages. We suspected a chick had just fledged from one burrow. We did not revise the population estimate calculated in 1987.

Tufted Puffin: Puffins were nesting in perimeter areas above rock bluffs or outcroppings in primarily Tufted Hairgrass habitat (Fig. SC020-2; Table SC020-5). The contents of four burrows were determined: two with adults incubating eggs and two with adults and newly hatched chicks. The sample was not large enough to calculate an occupancy rate, so we used the rate determined on Triangle Island in 1982 to estimate nesting populations.

1987 Population estimate:

Number of sample plots:	27 (27 m^2 - 0.2% of colony)
Average density:	5,550 ± 1,230 burrows/ha
Colony area:	1.7 ha
Total burrows:	9,352 ± 2,073
Occupancy rate: (from Triangle I.)	68 ± 4%
1987 Nesting population:	6,359 ± 1,410 pairs

Table SC020-5. Number of Tufted Puffin burrows in 1x1 m plots along transects on Sartine Island in July 1987. Plots considered outside the colony are indicated by a dash.

Plot	Transect						
	1	2	3	4	5	6	7
1	1	-	1	-	-	2	-
2	0	-	0	-	-	0	-
3	0	-	0	-	-	0	-
4	-	-	0	-	-	1	-
5	-	-	0	-	-		-
6-18	-	-	-	-	-		-
19	0		-	-			-
20	0		-	-			-
21	1		-	-			-
22	0		-	-			-
23	0		-	-			-
24	-		-	-			-
25	-		-	-			
26	-		-	-			
27	1		-	-			
28-44			-	-			
45			-	1			
46			-	1			
47			-	1			
48			2	0			
49				1			
50				1			
51				1			
52				0			

Associated species:

Bald Eagle - We saw two adults and one immature on 9 July 1987. One adult came off a ledge just below the high ridge crest at the north end of the main island, where we suspected a nest. Nesting was verified on 11 June 1989 - one half grown young was standing in a nest on a pinnacle at the north end. Two adults were perched above the nest. Three immatures were perched on slopes.

An eagle was seen taking a large gull chick on 13 July 1987.

Peregrine Falcon - One adult was flying around the island on 9 and 11 July 1987, and 11 June 1989. On 29 July 1989, two young flew off the mid-west cliffs.

Horned Puffin - One on 9 July 1987, and 11 June 1989. On 29 July 1989, there were six flying around and sitting on the southwest rocks.

Northwestern Crow - Three on 11 July 1987; nine on 29 July 1989.

Common Raven - Two on 9 July; three on 11 July 1987.

Other birds and mammals sighted:

Pacific Loon *Gavia arctica* - One flying by on 11 June 1989.

Surf Scoter *Melanitta perspicillata* - Two males and one female with puffins along the east side on 11 June 1989.

Wandering Tattler - One on 13 July 1987 and three on 29 July 1989.

Herring Gull - One adult on 29 July 1989.

Fox Sparrow - regular

Song Sparrow - regular

Harbour Seal - Four on 13 July 1987; two on 11 June 1989.

Northern Sea-lion - Sea-lions hauled out on the Sawtooth Rocks where we counted 183 on 9 July 1987; 492 on 11 June 1989; and 291 plus eight pups on 29 July 1989.

SC-030 BERESFORD ISLAND 103 I/15

Location: Southwest of Lanz Island. 50°47'25"N 128°46'15"W

Land status: Provincial Ecological Reserve.

Description: The main section is a 98 m high, dome-shaped island with steep, rocky sides. There are attached rocks and pinnacles at the northwest and south ends. With a total area of 14.5 ha, Beresford is the smallest of the Scott Islands. It has 5.6 ha of vegetated habitat. In the middle of the group, it exhibits transitional features between the large forested islands to the east and the treeless islands to the west. Slopes are grassy with areas of dense shrubbery like Triangle and Sartine islands, but there is an old stand of Sitka Spruce (*Picea sitchensis*) on the crest of the island. Many old trees have fallen, but their branches have continued to grow forming what appears to be a younger forest. Their large, old trunks laying on the ground are partially rotten and covered with thick mosses.

Tufted Hairgrass grows on exposed rocky edges, especially to the east and west, but *Elymus mollis* and *Calamagrostis nutkaensis* dominate most grassy slopes. *Conioselium pacificum* is frequent throughout grassy areas, and *Montia* sp. and *Maianthemum dilatatum* are profuse in small patches, especially on the western edge of the forest. *Carex* sp. mix with the grass and salmonberry on south slopes near the edge of the forest. Salmonberry is the most abundant shrub, occurring under the sparse stand of spruce and extending down part of the southern slope and much of the northern slope. Elderberry and twinberry are common under the trees. Highest sections of attached rocks and pinnacles are grassy.

Beresford Island was designated an Ecological Reserve in 1971.

Date of visit: 8, 20 July 1987 (transects or total counts for all species); 11 June 1989 (occupancy for Cassin's Auklets, counts of surface nesting species).

Colony access: Drop-off from boat.

Sensitivity: Beresford Island also supports high densities of breeding seabirds which are vulnerable to human disturbance. Vegetation is luxuriant and unavoidably trampled by explorers.

Observers: 1987: M. Lemon, M. Rodway, B. Carter, R. Chaundy. 1989: M. Rodway, K. Summers, B. Carter, D. Grinnell.

Census methods: **1987:** Two line transects with 112 plots, 1x1 m, were surveyed at near perpendicular bearings across the top of the island (Fig. SC030-1). Transect 1 was 254 m long at a bearing of 315°, and transect 2 was 301 m long at a 228° bearing. Slopes on transect 1 ranged from 0 to 60° and averaged 24°, and on transect 2 ranged from 2 to 50° and averaged 10°. Total counts were made of cormorant nests, gulls on territories and Pigeon Guillemots around the island.

1989: Occupancy for Cassin's Auklets was determined in four plots with 10 known burrows each. Plots were located along the first half of 1987 transect 1, spaced 30 m apart, beginning 15 m from the shore edge of the vegetation. Total counts were made of cormorant nests, gulls on territories and Pigeon Guillemots around the island.

Nesting species:

Storm-petrel: Storm-petrels were nesting in the centre of the island, primarily under the sparse forest (Fig. SC030-1; Table SC030-1). Burrows occurred in grass, forbs, around tree roots and fallen logs, and under dense salmonberry. They were also numerous in large, mossy logs, forming apartment-like complexes above the ground.

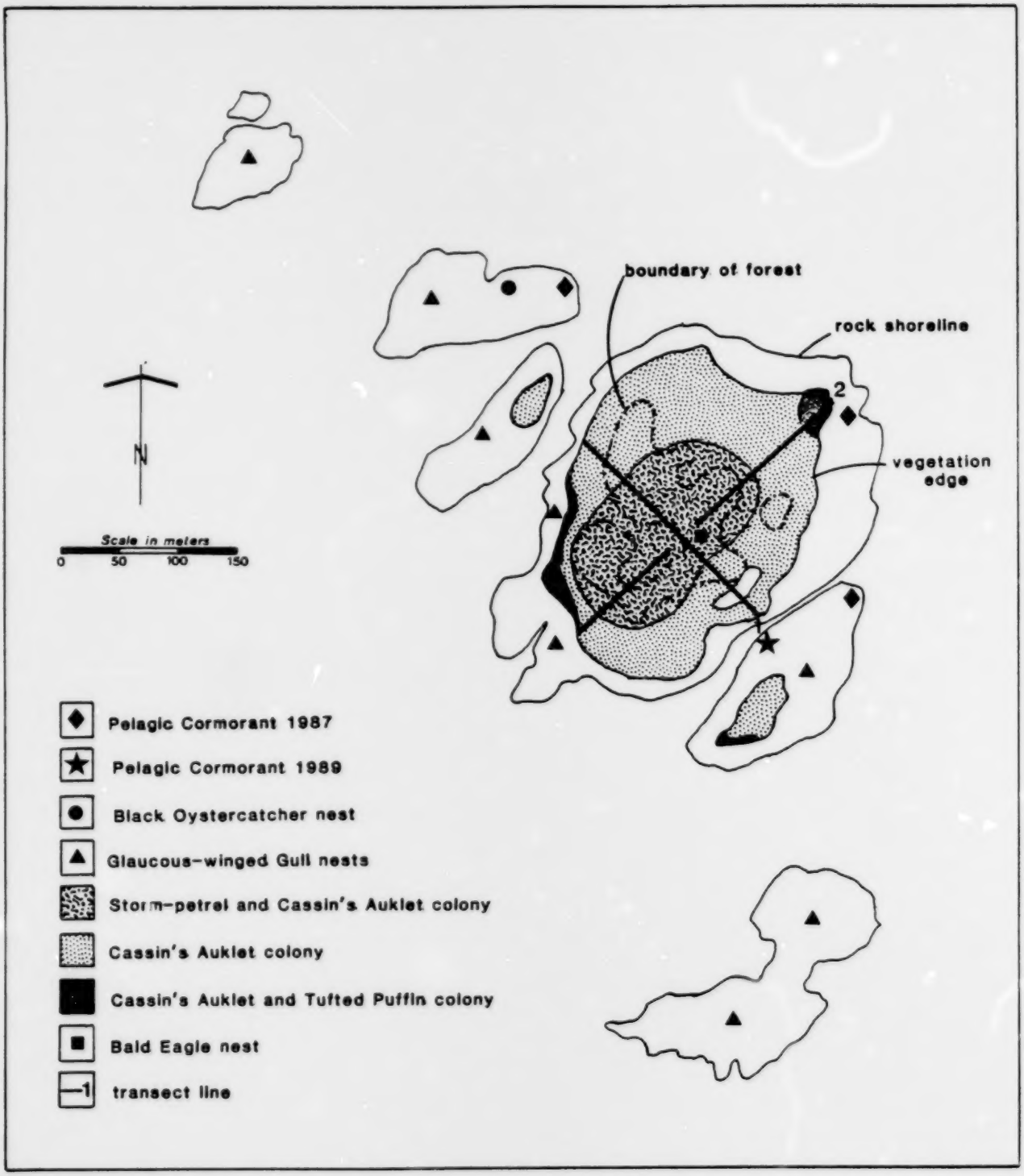

Figure SC030-1. Colony areas and transect locations on Beresford Island in 1987.

Table SC030-1. Number of storm-petrel burrows in 1x1 m plots along transects on Beresford Island in July 1987. Plots considered outside the colony are indicated by a dash. Plots along transect 2 indicated by an asterisk overlapped transect 1 and were not surveyed.

Plot	Transect 1	Transect 2	Plot	Transect 1	Transect 2	Plot	Transect 2
1	-	-	30	0	3	59	-
2	-	-	31	2	0	60	-
3	-	-	32	1	0	61	-
4	-	-	33	0	1		
5	-	-	34	0	0		
6	-	-	35	1	2		
7	-	-	36	0	0		
8	-	-	37	1	0		
9	-	-	38	1	*		
10	-	-	39	-	*		
11	-	-	40	-	*		
12	-	-	41	-	*		
13	-	-	42	-	*		
14	-	-	43	-	*		
15	-	-	44	-	*		
16	-	-	45	-	2		
17	-	-	46	-	1		
18	0	-	47	-	0		
19	0	-	48	-	4		
20	0	2	49	-	0		
21	1	1	50	-	0		
22	0	2	51	-	0		
23	0	3	52	-	2		
24	4	4	53	-	0		
25	4	2	54	-	2		
26	1	3	55	-	0		
27	0	0	56	-	-		
28	0	2	57	-	-		
29	0	3	58	-	-		

Table SC030-2. Occupancy of storm-petrel burrows along transects on Beresford Island in July 1987. Locations marked with an asterisk were in the vicinity of the listed plot.

						Fork-tailed Storm-Petrel			Leach's Storm-Petrel				
Occup. plot	Date	Tran	Plot	Empty	Cold egg	Adult + egg	Adult + chick	Fledged chick	Two adults	Adult on egg	Unknown	Total occupied	Total known
1	08/07	1	18*		1				1	1		3	3
2	08/07	1	21	1								0	1
3	08/07	1	24	1			1			2		3	4
4	08/07	1	31							1		1	1
5	08/07	1	31*			1				1	1	2	2
6	08/07	1	38							1		1	1
7	20/07	2	24							1	3	1	1
8	20/07	2	26*	2				1		3	2	4	6
9	20/07	2	28							1		1	1
10	20/07	2	48*							1		1	1
Totals				4	1	1	1	1	1	12	6	17	21

Fork-tailed and Leach's storm-petrels were found nesting in the same areas, though Leach's Storm-Petrels outnumbered Fork-tailed Storm-Petrels four to one (Table SC030-2). Data from occupancy plots gives some indication of breeding chronology of the two species. Except for one pair found in a burrow on 8 July, all Leach's Storm-Petrels were incubating eggs. A chick had already fledged from one Fork-tailed Storm-Petrel burrow on 20 July, though another burrow still contained an incubating adult on 8 July.

1987 Population estimate:

Number of sample plots:	50 (50 m^2 - 0.3% of colony)
Average density:	11,000 ± 1,857 burrows/ha
Colony area:	1.7 ha
Total burrows:	19,109 ± 3,226
1987 Occupancy rate:	81 ± 7% (17 of 21 known)
1987 Nesting population:	15,478 ± 2,950 pairs
Ratio of Fork-tailed to Leach's:	3:13
Fork-tailed Storm-Petrel:	2,941 ± 560 pairs
Leach's Storm-Petrel:	12,537 ± 2,390 pairs

Pelagic Cormorant: The main cormorant colony was located on the northeast point of the main section of the island in 1987. We counted 109 nests with adults sitting on them on 8 July, and 142 nests with adults sitting on 20 July. There were also 16 occupied nests on the east side of the middle northwest rock (counted 8 July), and three attended nests in a crevice on the north side of the south rock (counted 20 July). Using the maximum count on the northeast point gives a total of 161 nests for the island.

The contents of 14 nests on the northwest rocks were determined on 8 July: two empty; two with two eggs; four with three eggs; and six with four eggs.

On 11 June 1989, there were only six active nests on Beresford Island. They were located on the north side of the south rock, and were difficult to see from the water. We spotted them from the south slopes of the main island. There were three partially constructed nests and a total of 19 adults in breeding plumage in the same area. Some birds were carrying nesting material. There were no birds, nests or signs of nest building at sites used in 1987.

Black Oystercatcher: We found one nest with two eggs on the middle of the northwest rocks on 8 July 1987. The nest was an accumulation of jagged pebbles. One pair defended the nest, and five other birds were flying around the area. There were also seven birds flying around the northwest rocks on 11 June 1989, but no nests were located.

Glaucous-winged Gull: We counted gull nests on the middle and outer northwest rocks and estimated nesting pairs from counts of adults on territories in other areas on 8 July 1987 (Table SC030-3). The nesting population was estimated to be 145 pairs. Nests were made of grasses, *Cochlearia officinalis* and *Achillea millefolium*.

Table SC030-3. Glaucous-winged Gull nests and adults on territory on Beresford Island on 8 July 1987.

Location	Sta	Emp	1E	2E	3E	1E2Y	3Y	2Y	1Y	Ad	Est. Nests	Total nests
Outer NW rock	11	8	6	10	16		1	1	5*	140		58
Middle NW rock	5	4	4	1	9	1				18		24
Inner NW rock										32	16	16
W side cliffs										20	10	10
S end main										20	10	10
S rocks										54	27	27
Total	16	12	10	11	25	1	1	1	5*	288	63	145

* no chicks were seen but freshly hatched eggshells were present.

We counted an additional 253 adults and 50 immatures roosting on low rocks around the island on 8 July 1987.

There was insufficient time to conduct a nest count in 1989, but counts of adults on territories were made on 11 June (Table SC030-4). We estimated the nesting population to be 110 pairs. There were an additional 109 adults roosting on tidal rocks.

Table SC030-4. Glaucous-winged Gulls on territory on Beresford Island on 11 June 1989.

NW rocks	73
W side main	39
S end main	38
E side main	31
S rocks	34
Total	215

Pigeon Guillemot: We counted a total of 267 birds around the island at 1200 h on 8 July 1987. Most birds were on rocks or on the water along the northeast side of the main island and northwest rocks. There were 12 on the west side of the northwest rocks, 14 flew off cliffs on the west side of the island, and 21 were on the south rocks.

At 1130 h on 11 June 1989, a total of 146 were tallied: 135 along the northeast side, four on the west side of the northwest rocks and seven on the southwest side.

Cassin's Auklet: Cassin's Auklets burrows occurred in most vegetated portions of the island. They were abundant in grass or forb habitat and where salmonberry was less dense, but were sparse in high, dense salmonberry. Burrows were absent from a section of two meter high salmonberry and elderberry on the south slope of the island along transect 1 (Fig. SC030-1; Table SC030-5).

Most burrows checked were occupied, but a high proportion contained cold eggs, suggesting abandonment earlier in the season. Chicks were present in other burrows, and had fledged from one burrow (Table SC030-6).

Burrow length in a sample of 38 burrows ranged from 0.4 to 1.1 m and averaged 0.7 $\pm$ 0.2 m.

Table SC030-5. Number of Cassin's Auklet burrows in 1x1 m plots along transects on Beresford Island in July 1987. Plots considered outside the colony are indicated by a dash. Plots along transect 2 indicated by a star overlapped transect 1 and were not surveyed.

Plot	Transect 1	Transect 2	Plot	Transect 1	Transect 2	Plot	Transect 2
1	4	-	30	0	0	59	0
2	6	-	31	0	2	60	1
3	5	1	32	0	2	61	4
4	7	0	33	0	2		
5	2	2	34	0	0		
6	2	3	35	0	0		
7	0	0	36	0	3		
8	-	2	37	1	3		
9	-	1	38	0	*		
10	-	2	39	3	*		
11	0	1	40	1	*		
12	2	1	41	6	*		
13	1	0	42	2	*		
14	1	0	43	0	*		
15	0	4	44	1	*		
16	0	1	45	0	3		
17	3	3	46	0	1		
18	1	2	47	0	2		
19	2	2	48	0	0		
20	0	0	49	0	0		
21	2	0	50	1	0		
22	0	1	51	1	2		
23	2	1	52		0		
24	0	0	53		2		
25	1	0	54		0		
26	0	0	55		3		
27	0	4	56		6		
28	2	0	57		4		
29	0	1	58		3		

Table SC030-6. Occupancy of Cassin's Auklet burrows along transects on Beresford Island in July 1987. Locations marked with an asterisk were in the vicinity of the listed plot.

Occup. Plot	Date	Tran	Plot	Empty	Cold egg	Chick	Fledged chick	Unknown	Total occupied	Total known
1	08/07	1	5		1				1	1
2	08/07	1	5*		2	1		8	3	3
3	08/07	1	17*	1		1			1	2
4	08/07	1	18*				1		1	1
5	20/07	2	12		1				1	1
6	20/07	2	26*			2			2	2
Totals				1	4	4	1	8	9	10

1987 Population estimate:

Number of sample plots:	100 (100 m^2 - 0.2% of colony)
Average density:	13,400 ± 1,616 burrows/ha
Colony area:	5.5 ha
Total burrows:	73,408 ± 8,851
1987 Occupancy rate:	90 ± 10% (9 of 10 known)
1987 Nesting population:	66,067 ± 10,697 pairs

1989: Occupancy rate in the 40 burrows examined on 11 June 1989 was 80.0 ± 4.3%. It was similar to that determined in 1987. In the four plots of 10 known burrows each, there were 9, 7, 7 and 9 occupied burrows. In occupied burrows, we found five incubating adults, two cold eggs, and the rest were chicks of various ages. We suspected four chicks had fledged from burrows. We did not revise the population estimate calculated in 1987.

Tufted Puffin: Puffins were nesting primarily in perimeter Tufted Hairgrass habitat above cliffs on the northeast ridge and along the southwest side of the main island and south rock (Fig. SC030-1; Table SC030-7). Burrows occurred within 1-3 m of the edge along the southwest side, and as far as 30 m along the northeast ridge where Tufted Haigrass habitat was more extensive. Thirty-six burrows were counted on the middle of the northwest rocks. The total on that rock was estimated to be twice what was counted. Birds were also seen sitting on and flying around large rocks at the base of salmonberry slopes on the north side of the northeast ridge.

Table SC030-7. Number of Tufted Puffin burrows in 1x1 m plots along transects on Beresford Island in July 1987. Plots considered outside the colony are indicated by a dash.

Transect	Plot											
	1	2	3	4	5	6	7	8	9	10	11-60	61
1	-	-	-	-	-	-	-	-	-	-	-	-
2	2	3	2	2	0	1	1	-	-	-	-	0

Occupancy rate was not determined on Beresford Island, and we used the rate determined on Triangle Island in 1982 to calculate nesting populations. The contents of five burrows examined on the west side of the main island and on the middle northwest rock on 8 July were: four with incubating adults and one with a freshly hatched eggshell. Adults were carrying fish on 20 July.

1987 Population estimate:

Number of sample plots:	8 (8 m^2 - 0.4% of colony)
Average density:	13,750 ± 3,750 burrows/ha
Colony area:	0.2 ha
Total burrows:	3,121 ± 851
Occupancy rate: (from Triangle I.)	68 ± 4%
1987 Nesting population:	2,122 ± 579 pairs

Associated species:

Bald Eagle - One nest was located 10 m high in a 20 m high spruce on the south slope of the island, about 100 m from the southern edge of the vegetation. One large young was standing in the nest on 8 July 1987. When we returned on 20 July, the young had fledged, but was still sitting near the nest. An old nest was found in a fallen tree about 70 m inland from the active nest.

There were two adults perched in high trees and four immatures on the northwest rocks on 11 June 1989. We saw no activity around the eagle nest when we were on the island.

Peregrine Falcon - One adult flew off the north cliffs at 1200 h and one male was perched on the west point of the vegetated south rock at 1330 h on 8 July 1987. A pair was very excited around the north cliffs on 20 July. On 11 June 1989, an excited pair were observed on the south side of the island.

Common Murre - Five on the water along the east side on 20 July 1987.

Ancient Murrelet - Two adults on the water along the west side on 11 June 1989.

Horned Puffin - Seven were flying from the northwest rocks on 8 July 1987. On 20 July, one bird was observed circling the slope on the north side of the northeast ridge. The bird landed at the base of the vegetation on top of a large jumble of rocks and disappeared into a hole. One minute later a bird flew out and headed due south in a direct line as far as was visible. We assumed this behavior indicated an incubation shift, but could not verify nesting. We saw one bird on the water on the west of the island on 11 June 1989.

Northwestern Crow - Nine were flying around on 8 July 1987. One nest was found 2.5 m above the ground on a low spruce branch in the middle of the island. One chick was on the ground below the nest. A fledged young was seen below the eagle nest. We saw four crows on 11 June 1989.

Other birds and mammals sighted:

Northern Fulmar - One dark phase bird was sighted on the water near the north rocks on 8 July 1987.

Winter Wren - Seen around shrubby and forested areas.

Swainson's Thrush - One on 8 July 1987.

Orange-crowned Warbler - A suspected family of three was observed on 8 July 1987.

Fox Sparrow - Two birds were carrying food on 8 July 1987.

Song Sparrow - common.

Red Crossbill - Six in flock on spruce tree on 20 July 1987.

Northern Sea-lion - Sea-lions hauled out on low rocks to the north and south. We counted a total of 441 on 8 July 1987: 59 on the south rocks and 382 on the north rocks. Numerous pups were sighted on the north rocks. Three large bulls were visible on the north rocks and one was noted on the south rock.

A total of 269 were counted on 11 June 1989: 59 on the south rocks and 210 on the north rocks. Eight bulls were recorded on the north rocks and four were seen on the south rocks.

SC-040 LANZ ISLAND 103 I/15

Location: The second of the Scott Islands west of Cape Scott. 50°49'N 128°41'W

Land status: Provincial Crown Land.

Description: Lanz Island has a rugged, rocky shoreline with many pinnacles, cliffs, crevices and precipitous slopes, plus numerous small bays and high-tide cobblestone beaches. There is a larger bay with a sandy beach on the east side. Interior slopes rise to a maximum elevation of 212 m (Fig. SC040-1). The island has a total area of 764 ha, 692 of which are forested.

Most slopes near shore are shrub covered under a spruce, hemlock (*Tsuga heterophylla*) and redcedar (*Thuja plicata*) forest. Salal is predominant on southern exposures, especially in areas of old windfall, and salmonberry is more abundant on eastern and northern slopes and above rock bluffs near the southwest corner. Twinberry, elderberry and willows (*Salix* sp.) are common, mixed with salal and salmonberry along shore. Bare litter areas with scattered Lady Fern were found under densely canopied spruce towards the southwest corner. Grass, primarily *Calamagrostis nutkaensis*, and forbs grow along much of the forest fringe. There is one extensive grassy area on the southwest point. Young spruce are expanding over this area and many dead grass tussocks are visible under small saplings. Much of the forest on higher slopes appears diseased.

Date of visit: 5 to 21 July 1987.

Colony access: Boat landings are easiest on the sandy beach on the east side of the island. We also landed on a small isthmus at the north end of the west side. Drop-offs from the boat were made to explore other areas.

Base camp: Good camping with water is available on the sandy beach on the east side. High tides wash all sandy areas, and tents are best pitched in the forest. Tent space is limited.

Observers: M. Lemon, M. Rodway, B. Carter, R. Chaundy.

Census methods: Exploration and total count.

Nesting species:

Pelagic Cormorant: An abandoned cormorant nest site was located on dissected cliffs on the south side of the island (Fig. SC040-1). We counted 56 nests from close proximity on shore on 10 July. All nests had been built that season and were in excellent repair. Eggs or eggshells were visible in two nests, and one depredated egg was found on the adjacent point. No cormorants were present.

Flocks were regularly seen feeding between Lanz and Cox islands. Twenty birds in breeding plumage and 20 nonbreeding birds were sighted on 6 July. There were 70 nonbreeding birds along the south side on 7 July.

Pigeon Guillemot: Pigeon Guillemots were suspected nesting at two locations: at the northeast and southwest corners. Seven birds were sighted at the northeast corner at 1100 h on 7 July - one of which flew off the cliffs - and 19 were counted on the water at the southwest corner at 2200 h on 11 July. Nesting was not confirmed.

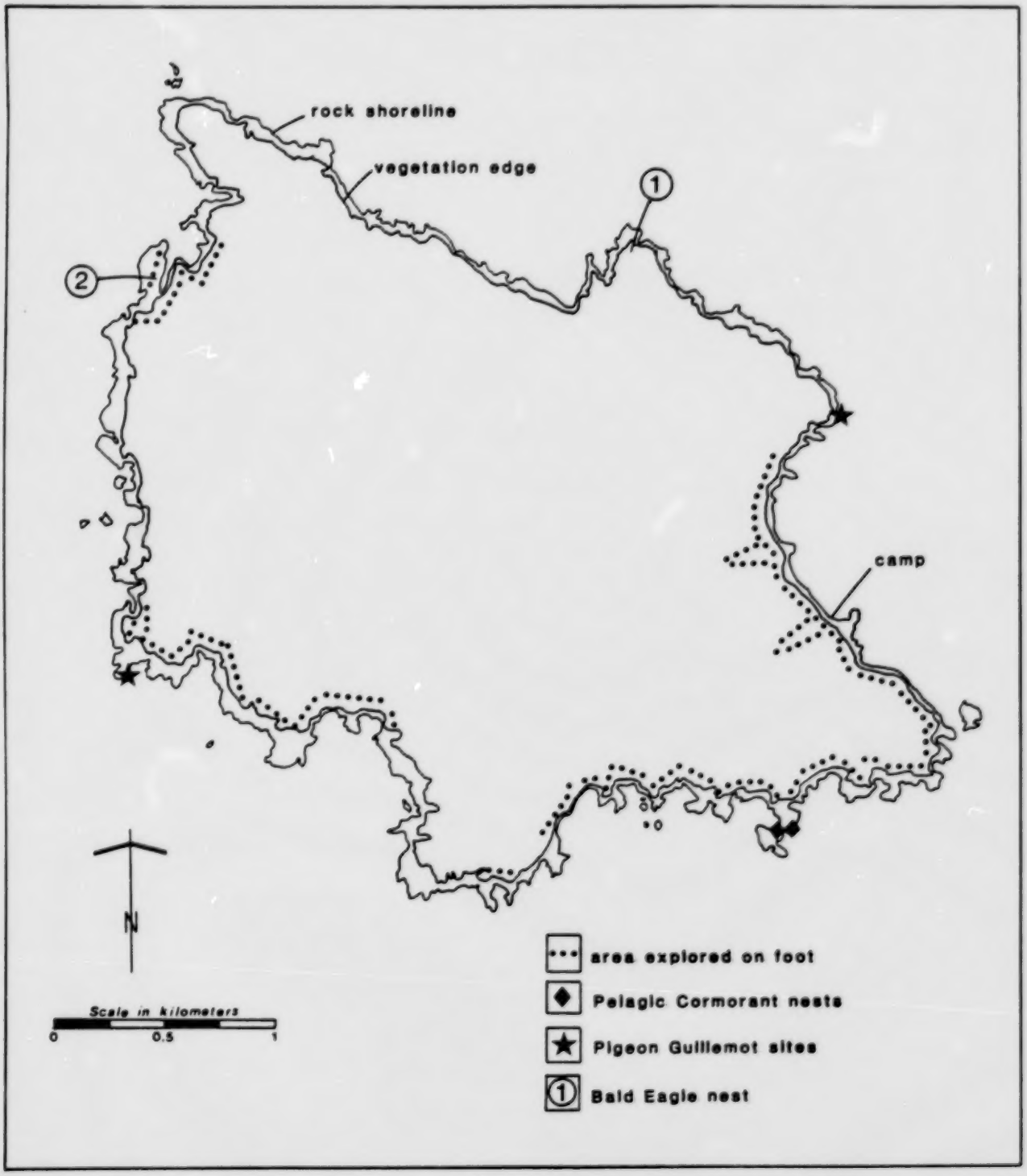

Figure SC040-1. Nest sites and areas explored on Lanz Island in 1987.

Cassin's Auklet: Small numbers of Cassin's Auklets appeared to be attempting to nest in the grassy area on the southwest point, but were being caught by mink (*Mustela vison*). Two Cassin's Auklet sized burrows were found on 7 July. Their tunnels felt worn but their entrances were not. Six feather piles were encountered in the same area - one with a Cassin's Auklet foot, and another with attached wings, vertebrae and feet. Depredated remains were in tunnels under thick grass coverings and were not from aerial predators. There were large piles of mink scats, some of which were composed entirely of feathers, and numerous mink trails in the area. Carl *et al.* (1951) reported abandoned burrows on all grassy headlands in 1950.

Associated species:

Turbulent channels between Lanz and Cox islands attracted many feeding seabirds and most sightings of seabird species were made in that area.

Bald Eagle - Two nests were located (Fig. SC040-1). One on the north side was 15 m high in a 20 m spruce at the edge of vegetation. Two adults were perched in the tree on 7 July. The other near the north end of the west side was on the inner of two small islets. It was on the top of a 15 m high, broken spruce. One large young was standing in the nest and one adult was flying in the vicinity on 7 July.

Two adults were seen around camp on 5 July.

Peregrine Falcon - A pair of falcons was flushed out of a gorge just east of the southwest point.

Glaucous-winged Gull: - 50 immatures and 96 adults on 5 July.

Common Murre - Six on 9 July.

Marbled Murrelet - Three in summer plumage were sighted off the north side and one in winter plumage was in the east bay on 9 July. Two summer birds were in the east bay on 10 July.

Ancient Murrelet - One adult off the northwest corner on 19 July.

Rhinoceros Auklet: Rhinoceros Auklets foraged around the island through the day, but generally dispersed by 2100-2200 h. Many were observed carrying fish. We estimated 210 in the channel east of camp on 5 July. About 180 were flying west along the south side at 2000 h on 7 July. On 20 July at 2000 h, there were 500 birds feeding along the south and east sides. Over 100 had bill loads of Sandlance (*Ammodytes hexapterus*).

Tufted Puffin - Two on the water along the south side on 7 July, and three in the east channel on 12 July.

Horned Puffin - One off the northwest corner on 19 July.

Northwestern Crow - Flock of 50 above the east bay on 6 July.

Common Raven - Two on 6 July.

Other birds and mammals sighted:

Pacific Loon - Two in breeding plumage and two molting birds on 5 July; one breeding plumage and 9 winter plumage on 8 July.

Common Loon - One in breeding plumage and 11 in winter plumage on 5 July.

White-winged Scoter *Melanitta fusca* - One or two immature or molting males were present through most of our stay.

Surf Scoter - One male on 10 July.

Semipalmated Plover *Charadrius semipalmatus* - One on the east beach on 20 July.

Red-necked Phalarope *Phalaropus lobatus* - Flocks of 20 and 30 flying past the southwest corner on 8 July. A string of 110 were feeding along a tide line south of the pass between Lanz and Cox islands on 20 July. Few had some red on their necks, but most were in predominantly winter plumage.

Herring Gull - One adult on 5 July; one second-year bird on 10 July.

Rufous Hummingbird - One on 7 and 9 July.

The following passerines were seen or heard regularly during our stay:

Western Flycatcher
Chestnut-backed Chickadee *Parus rufescens* - seen on west side.
Winter Wren
Golden-crowned Kinglet *Regulus satrapa*
Swainson's Thrush
Hermit Thrush *Catharus guttatus*
American Robin *Turdus migratorius*
Varied Thrush *Ixoreus naevius*
Orange-crowned Warbler
Townsend's Warbler *Dendroica townsendi*
Fox Sparrow
Song Sparrow
Red Crossbill - 30 on 9 July.

Deer mouse - Common around camp.

River Otter *Lutra canadensis* - Scats and trails on the southeast knobs. Many large, purple sea-urchin shells were scattered about.

Mink: Mink were introduced to Lanz Island in the late 1930's (Carl *et al.* 1951) and are now common in all perimeter areas. One live animal was spotted at the southwest corner on 7 July, and one dead one was found on the east beach on 5 July. Abundant sign was encountered in all areas explored. There were mink burrows on many rocky knobs along shore.

Harbour Seal - 26 in bay near north end of west side on 7 July.

SC-050 COX ISLAND 103 I/15

Location: West of Cape Scott. 50°48'N 128°36'W

Land status: Provincial Crown Land.

Description: Similar to Lanz Island, Cox Island has a rugged shoreline with many bays and high-tide beaches between and around numerous pinnacles, cliffs, gorges and steep, rocky ridges (Fig. SC050-1). The island rises to a maximum elevation of 312 m and has an area of 978 ha. Sedimentary shelves on the northeast side have many ammonite fossils. Salal and salmonberry dominate the understory of the spruce, hemlock and redcedar forest that covers 880 ha of the island. Grass and forbs fringe forest slopes, especially above steep rock faces, but there are no extensive grassy areas. Behind the large northern bay, the forest appears diseased, many trees looking spindly and probably dying.

There is a wreck of an old Riv-Tow barge on the west side of the large south bay.

Date of visit: 12, 14 and 20 July 1987.

Colony access: We landed the boat on the beach at the northwest corner and on the middle of the north side of the island. We dropped off explorers in other areas.

Observers: M. Lemon, M. Rodway, B. Carter, R. Chaundy.

Census methods: Exploration and total count.

Nesting species:

Pelagic Cormorant: We found two nesting sites on 12 July. There were two nests in a cave on the northeast side, and 76 nests on the west side of the large, mid-south bay near the barge remains. No birds were attending the nests in the cave, though one breeding adult was flying in the area, and 13 immatures were roosting on the cliffs nearby. Three adults were sitting on nests on the south side, the rest were unattended. Twelve breeding birds and 38 immatures were roosting on low rocks below nests. When we returned on 20 July there were no adults present and only two immatures roosting.

A large flock of cormorants regularly roosted on a rock at the west tip of the island, facing the channel between Cox and Lanz islands. Most were immature or nonbreeding birds. We counted 115 on 5 July, one of which had white breeding patches, and 230, including five in breeding plumage, on 12 July. A flock of 140 was seen on the water off the south side on 14 July.

Cassin's Auklets were suspected nesting on Cox Island by Carl *et al.* (1951). No evidence of burrow-nesting species was found during our explorations.

Associated species:

Bald Eagle - We located five Bald Eagle nests, but only three appeared active on 12 July (Fig. SC050-1):

1. At west end of large, mid-north beach, 30 m high in 35 m spruce 10 m from the beach. No adults in the vicinity.
2. At the base of the northeast headland at the crest of the slope, on top of 25 m high broken snag. One adult soaring.
3. On the south side, west of the large, middle bay, 20 m high in 25 m spruce on a small ridge between two bays. One large feathered young in nest and one adult perched in tree.

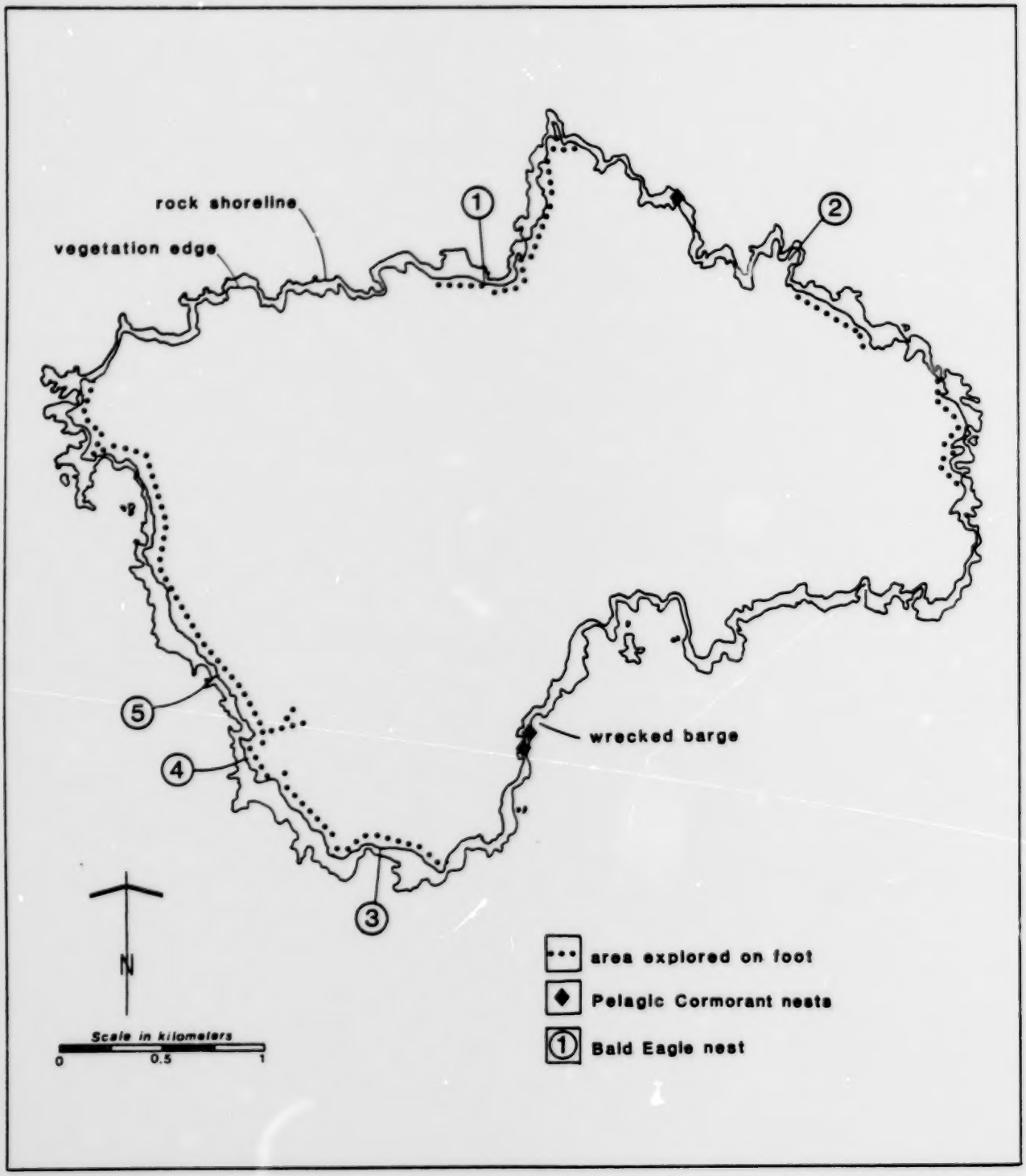

Figure SC050-1. Nest sites and areas explored on Cox Island in 1987.

4. On rocky point north of the southwest corner, on top of 25 m high snag, 10 m from shore rock. One adult perched on point.
5. About 0.5 km north of southwest point, 30 m high in 40 m snag, 20 m from shore. No activity.

Two adults and six immatures were flushed out of a small beach on the east end on 12 July.

Peregrine Falcon - Three falcons that we suspected were a pair with a fledged young, flew off the cliffs on the mid-northeast side on 12 July.

Glaucous-winged Gull - Groups were regularly roosting on the west tip of the island. About 200 immatures and 100 adults on 5 July.

Marbled Murrelet - One in winter plumage off the east side on 12 July.

Common Raven - One on the north side on 12 July.

Other birds and mammals sighted:

Sooty Shearwater - At 1400 h on 6 July, shearwaters were streaming southwest through Scott Channel at a rate of 30-50 birds per minute. On 7 July at 1000 h they were flying north at 10-20 birds per minute.

The following passerines were seen or heard during explorations:

Chestnut-sided Chickadee
Winter Wren
Swainson's Thrush
Hermit Thrush
Orange-crowned Warbler
Fox Sparrow
Song Sparrow

Raccoon *Procyon lotor* - Raccoon were introduced to Cox Island at the same time mink were introduced to Lanz Island (Carl *et al.* 1951). Scats and tracks were abundant in all shoreline areas explored. Scats were composed of crabs, mussels and limpets.

Mink - Mink scats were encountered in most areas, though sign of mink was not as abundant as that of raccoon. Mink must have colonized the island from Lanz Island where they were introduced.

Harbour Seal - Over 20 were seen scattered in bays around the island on 12 July.

SUMMARY AND CONCLUSIONS

The Scott Islands are the most important breeding grounds for seabirds in British Columbia. The outer three islands in the group support over two million breeding birds, 38% of the total seabird breeding population in the province (Table SC-1; Rodway *in press*). They are the most important colonies for Cassin's Auklets in the world, housing 58% of their estimated world population (Rodway *in press*).

Changes in the number of breeding birds were noted over the seven year time span covered by this report. Most of those changes appeared to be seasonal fluctuations in response to environmental conditions. In 1984, surface nesting species suffered almost total reproductive failure, and breeding efforts of Tufted Puffins and growth rates of Rhinoceros Auklets were low. Those failures were attributed to a week of severe storms at the end of June combined with a shortage of sandlance, the primary prey for fish-eating species (Rodway *et al. in prep).*

Increases in population estimates for Cassin's Auklets between 1977 and 1989, and Tufted Puffins between 1982 and 1989 were largely due to higher burrow occupancy rates in 1989. Occupancy rates are an indication of seasonal breeding efforts, and those increases likely reflect changes in environmental conditions, rather than actual population changes.

For Rhinoceros Auklets, increases in population estimates between 1976, 1984 and 1989 appear to indicate actual population change, though they were partially due to more intensive survey methodology. Colony area in the south bay expanded during each interval. Changes in the north bay are more difficult to interpret, but historical records suggest that the colony there was established sometime between 1949 and 1977, and has probably expanded since.

Impact of the Nestucca oil spill on breeding populations in 1989:

In 1989, all species except Common Murres were nesting in larger numbers than previously recorded. Occupancy rates of burrow nesting species were higher and numbers of nests of surface nesting species were greater than those recorded on past surveys. The mortality of Cassin's Auklets during the oil spill had no detectable impact on breeding populations in the Scott Islands. The same was true on Solander Island, along the west coast of Vancouver Island, where the occupancy rate of Cassin's Auklet burrows on 28 and 29 May 1989 was 84.4 $\pm$ 6.5%, and burrow density was 11,754 $\pm$ 1,198 (N = 67, plots 2x2 m^2), similar to that estimated in 1988 (Rodway unpubl.; Kruskal-Wallis results: t = 2.2920; p = 0.13). Estimated nesting population on Solander Island in 1989 was 33,886 $\pm$ 4,321 pairs

More Common Murres were counted in 1989 than in previous seasons, but increases were due largely to more complete coverage of colony areas. Comparable counts at specific nesting sites in 1982, 1985 and 1989 were highest in 1982 and lowest in 1985. There was no apparent decline in numbers of murres as a result of the oil spill.

Common Murres were not as successful as other species in 1989. Almost all birds on the east side of the island, representing about 15% of the total population, bred unsuccessfully, and the ratio of breeding birds to total birds present on the study site on Puffin Rock was lower than all other values reported in the literature. Lack of comparative data from previous seasons precluded evaluation of those events and their possible relationship to the Nestucca oil spill.

There was no evidence that the Nestucca oil spill affected seabird breeding populations in the Scott Islands, or on Solander Island during the summer of 1989. No oiled, live or dead birds were sighted. The reproductive success of Common Murres could not be evaluated due to lack of baseline data.

Table SC-1. Current summary of seabird breeding populations in the Scott Islands (pairs, except numbers in brackets and totals which are given in total birds). Acronyms for species names follow Campbell and Harcombe (1985).

SITE CODE	SITE NAME	FTSP	LSPE	BRCO	PECO	BLOY	GWGU	COMU	TBMU	PIGU	CAAU	RHAU	TUPU	HOPU	TOTAL BIRDS
SC-010	Triangle I.	100e	200e		433	25	577e	4100	7e(41)	x(331)	548000t	41700t	26400t	S(4)	1,243,419
SC-020	Sartine I.			39	168	1S	390e	0(113)		x(116)	376000t		6400t	S(6)	766,118
SC-030	Beresford I.	2900t	12500t		6	3S	110e	0		x(146)	66000t		2100t	S(1)	167,385
SC-040	Lanz Island				56(0)					S(26)	0	0			138
SC-050	Cox Island				78(0)										156
Total nesting pairs		3000	12700	39	741	29	1077	4100	7		990000	41700	34900		
Total breeding birds		6000	25400	78	1482	58	2154	8200	14	619	1980000	83400	69800	11	2,177,216

e: population estimated from numbers of breeding birds seen.

x: breeding confirmed but population not estimated.

t: population estimate derived from systematic sampling along transects.

(): number of birds in breeding plumage sighted around the colony.

LITERATURE CITED

Bertram, D.F. & Kaiser, G.W. 1988. Monitoring growth and diet of nestling Rhinoceros Auklets to gauge prey availability. Technical Report Series No. 48. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 45pp.

Birkhead, T.R. and Nettleship, D.N. 1980. Census methods for murres, *Uria* species: a unified approach. Canadian Wildlife Service Occasional Paper 43. 25pp.

Birkhead, T.R., Johnson, S.D. and Nettleship, D.N. 1986. Field observations of a possible hybrid murre *Uria aalge* X *Uria lomvia*. Canadian Field-Naturalist 100(1):115-117.

Burger, A.E. *In prep.* Effects of the Nestucca oil spill on seabirds along the southwest coast of Vancouver in 1989. Technical Report Series. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Butler, R.W., Lemon, M. and Rodway, M. 1985. Northwestern Crows in a Rhinoceros Auklet colony: predators and scavengers. Murrelet 66:86-90.

Campbell, R.W. and Harcombe, A.P. 1985. Wildlife habitat handbooks for British Columbia: standard taxonomic list and codes of amphibians, reptiles, birds and mammals. Wildlife Habitat Research WHR-20, Wildlife Report No. R-11. Royal British Columbia Museum, Victoria.

Carl, G.C., Guiguet, C.J. & Hardy, G.A. 1951. Biology of the Scott Island Group, British Columbia. Provincial Museum of Natural History and Anthropology Report for the year 1950, Victoria. pp.21-63.

Hancock, D. 1970. New Rhinoceros Auklet colony for British Columbia. Condor 72:491.

Harris, M.P. 1984. The Puffin. T & A D Poyser, Calton.

Kendall, M.G. and Stuart, A. *The Advanced Theory of Statistics Vol. I.* (2nd ed.). Hafner Publishing Co., N.Y.

Lemon, M., Rodway, M. & Vallee, A. 1983. Census of Tufted Puffins breeding on Triangle Island in 1982. Unpubl. rept. Canadian Wildlife Service, Pacific and Yukon Region, Delta.

Nettleship, D.N. 1976. Census techniques for seabirds of arctic and eastern Canada. Canadian Wildlife Service Occassional Paper No. 25.

Rodway, M.S. 1988. British Columbia Seabird Colony Inventory: Report #3 - Census of Glaucous-winged Gulls, Pelagic Cormorants, Black Oystercatchers, and Pigeon Guillemots in the Queen Charlotte Islands, 1986. Technical Report Series No. 43. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 95pp.

Rodway, M.S. 1990. Attendance patterns, hatching chronology and breeding population of Common Murres on Triangle Island, British Columbia following the Nestucca oil spill. Technical Report Series No. 87. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 46pp.

Rodway, M.S. *In press.* Status and conservation of breeding seabirds in British Columbia. *In:* Croxall, J.P. (ed.). *A supplement to: Status and conservation of the world's seabirds.* ICBP Technical Publication.

Rodway, M.S., Bertram, D.F. and Lemon, M.J.F. *In prep.* Seabird nesting failure on Triangle Island, British Columbia in 1984.

Rodway, M.S., Lemon, M.J.F. & Kaiser, G.W. 1988. British Columbia Seabird Colony Inventory: Report #1 - East Coast Moresby Island. Technical Report Series No. 50. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. 276pp.

Rodway, M.S., Lemon, M.J.F. & Kaiser, G.W. 1990. British Columbia Seabird Colony Inventory: Report #2 - West Coast Moresby Island. Technical Report Series No. 65. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Rodway, M.S., Lemon, M.J.F., Savard, J-P. & McKelvey, R. 1989. Nestucca oil spill: impact assessment on avian populations and habitat. Technical Report Series No. 66. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Savard, J.-P.L. & Smith, G.E.J. 1985. Comparison of survey techniques for burrow-nesting seabirds. Canadian Wildlife Service progress report No. 151. 7pp.

Vallée, A. & Cannings [illegible] J. 1983. Nesting of the Thick-billed Murre, *Uria lomvia*, in British Columbia. Canadi[illegible] Field-Naturalist 97:450-451.

Vermeer, K. 1978. Extensive reproductive failure of Rhinoceros Auklets and Tufted Puffins. Ibis 120:112.

Vermeer, K. 1979. Nesting requirements, food and breeding distribution of Rhinoceros Auklets, *Cerorhinca monocerata*, and Tufted Puffins, *Lunda cirrhata*. Ardea 67:101-110.

Vermeer, K. and Summers, K.R. Unpubl. Comparison of aspects of ecology of Rhinoceros Auklets and Tufted Puffins on Triangle Island, British Columbia. Canadian Wildlife Service unpubl. report.

Vermeer, K., Manuwal, D.A. & Bingham, D.S. 1976a. Seabirds and pinnipeds of Sartine Island, Scott Island group, British Columbia. Murrelet 57:14-16.

Vermeer, K., Summers, K.R. and Bingham, D.S. 1976b. Birds observed at Triangle Island, British Columbia, 1974 and 1975. Murrelet 57:35-42.

Vermeer, K., Vermeer, R.A., Summers, K.R. & Billings, R.R. 1979. Numbers and habitat selection of Cassin's Auklet breeding on Triangle Island, British Columbia. Auk 96:143-151.

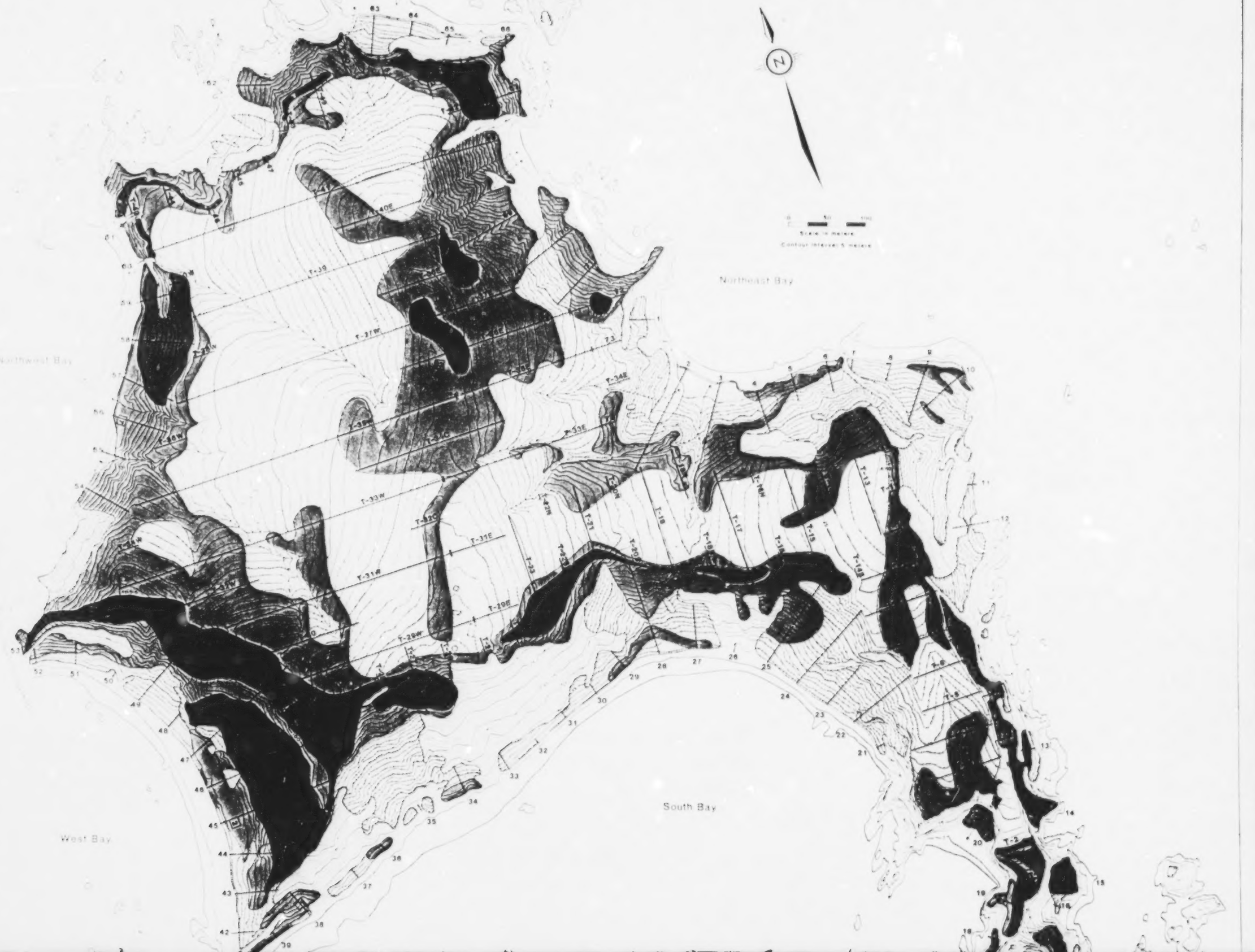
N
Northwest Bay
Northwest Bay
South Bay
West Bay

Figure SC010-2 Cassin's Auklet colony and transect locations on Triangle Island in 1989

Figure 5C(1)-4. Rhinoceros Auklet and Tufted Puffin colony and locations of surface nesting species on Triangle Island in 1989.